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THE MOUNT LOWE RAILWAY OBSERVATORY.*

EDGAR L. LARKIN, DIRECTOR.

THE CELESTIAL VAULT.

FOR POPULAR ASTRONOMY.

Removal from observatories in Illinois, latitude 41° 13′ and latitude 40° 55′ 16″, to one larger and better in California, latitude 34° 17′ 44″, and altitude 3420 feet, is comparable doubtless to translation into another world. It is to the splendid air that the glory revealed by the change is due. The atmosphere is pure, without currents or distortion, while its transparency is equal to that of the objective. Here on this mountain top, above the troubled world, the stellar hosts burn and blaze and flash their true colors in lavish display. With a climate, whose loveliness it were useless to attempt to describe, whose mildness day and night throughout the year makes observations possible without physical discomfort, instrumental manipulation is a pleasure. Cold is unknown, frost never appears on the eye-pieces nor moisture, and weather annoyances seldom interfere, except during the rainy season in January and February. A description of the Milky Way is beyond the power of human speech especially when Scorpio and Saggittarius hang their sidereal sheets over the sea. When fog obscures the ocean, plain and city, these curtains of the sky are let down even to the mists hovering over the watery wastes. They are silver white and shimmer to the unaided eye with a supernal radiance. But when the telescope is turned full on the starry heaps a scene of matchless splendor is on display. It is impossible to realize the complexity of the Galaxy without seeing it, and then it is far more impossible. The stellar diamonds, rubies and sapphires are strewn in sprays, wisps, spirals and curves, and are scattered like a cosmical hail on jet black layers of space. The dark openings are impressive, always so when suddenly swept into field. The starless areas present a startling appearance, after moving from dense regions.

The vacancy in α, $16^h\ 46^m$ and δ, $-15°\ 22'$, affords no star even in the air of California, and no stellar point can be seen in

* Los Angeles County, Southern California, U. S. A.

α, $17^h\ 21^m$, δ, $-26°\ 48'$. Barnard or Roberts might record an image by suitable exposure. In coming south, an extra zone of 7° is lifted up: it is filled with wonders. Among these is the unspeakable splendor of the cluster, Omega Centauri, in α, $13^h\ 20^m$, δ, $-46°\ 41'$. It is visible without optical aid as a hazy sphere, but in the 16-inch the scene is awe-inspiring. Its area is much greater than that of M 13 in Hercules, the stars smaller and more closely packed in the center. The Trifid and Omega nebulæ present details unseen in the East, and the glory of the Trifid can be seen without glasses after once locating it with the refractor. It is a pleasure to have a horizon; at times it is possible to see stars in the south, within 2° of the water when the sea is joyful, not hiding his face in mist. But, even when thin vapors rest on the waves, the fierce rays of Canopus penetrate with the force of fiery darts. It is interesting to watch the career of low down stars, rising out of the sea, traversing their little arcs to culmination, then their descent and plunge beneath the waves. At sunsets in December and January, it is common to see the exact half of the Sun above the water; in which case an ocean steamer has the dimensions of an ordinary sunspot.

The colors of the stars seem to be more pronounced than in observatories in higher latitudes, the blue is more intense, the yellow brighter, the scarlet in deeper shade, while Hind's red star in Lepus is seen blazing with crimson.

The zodiacal light is far wider at the base and higher to the apex, while its brilliancy, by estimation, is easily twice, perhaps three times, greater than if seen from an eastern standpoint. And what shall be said of Orion? It is simply enshrouded in nebula. In the blackest midnight the nebulosity is observed in all parts of this wide constellation. At first, the idea of complete submergence was not thought possible, but the sky of Orion really shines with continuous nebular radiance. The great nebula is estimated to be at least of twice the area usually seen in the East, while outlying streamers, filaments and curved feather-like tracery are observed on nearly all sides of this stupendous cosmical body. The Andromeda nebula displays intricate convolutions as shown in photographs, and has the appearance of a rudimentary solar system.

Spectroscopy.

A field is opened here for spectroscopic exploration on telluric lines and bands. From the east round through the north to west the horizon is made up of mountains, while the sea extends

from west through south to east. The peaks on the east are in some places polished by winds, notched in others, while many are covered with shrubs, low lying thickets, balsamic perennials, and flowering plants. Their altitudes range from 4° to 12° above the Observatory, and distance from 2000 to 4500 feet. Piles of loose stones rest on a few of the summits and these together with the leaves of the bushes gather Mojave's dust. Now this entire outline possesses peculiar properties in their action on light, and it is expected that these will throughout the year of alternations of wet and dry, wind and calm, dust and damp, present opportunity for spectroscopic study.

At times the adjacent air is chemically pure, without either dust or aqueous vapor. Double stars emerge from granite and from the leaves when winds are stilled. Gamma Leonis comes out of a rift split in stone and Castor from a leafy twig, and four of the six stars in the trapezium of Orion have been seen standing on smooth rock at the instant of rising, while the nebula suffered but little loss of light. It is a marvel to see the rising Pleiades or Galaxy, with the myriad stars, issuing from granite. From some delusion the speed of the Earth's rotation appears to be accelerated, for bodies rising on these summits, over the velocity at meridian transit. The effect with wide eyepieces is startling, for owing to reversal the sidereal hosts, seem to be pouring in floods into the blackness of the canyon yawning below. To learn how sunlight is affected as it passes near the surface of rocks the mirror of the heliostat is turned on the point where the Sun will appear tangent to the mountain surface, all adjustments of slit, collimator, view telescope and clock, having been made the day before, all is in readiness with the spectroscope to observe the first beams gliding over rocks, rough or polished, or flashing between branches and leaves as the case may be. At the last observation, the rays came from stone, the slit being focused on the two sodium lines. Two extra lines were seen between D_1 and the nickel line λ 6893.098. They were apparently as thick as a spider's web.

At sunset on the same day seven lines were seen between the two D's, the horizon being composed of peaks extending 60 miles to the sea. Telluric lines usually begin at the 4th hour or 5th in summer, when the Sun is on the mountains, and come in rapidly on the 6th. In winter—Sun south—the lines develop earlier, but much depends on the condition of the ocean, or the vapors above it. On the day when two extras were seen at sunrise and seven at sunset, 52 were counted from D_3 to an equal distance on the

other side of D_1. This was in June, both horizons being mountains, one near the sea. Once, in December, when the Sun was on the water, ten lines beside the one due to nickel appeared between the two caused by the oscillation of sodium atoms. This mountain horizon on the east is a never-ending object of fascination with its sublimity of rising stars, and advance of stellar hosts. And now comes Jupiter dragging his moons out of some stony cavern, and Saturn uplifts his rings in triumph from clefts and rifts. How beautiful are the binaries, and that triple 919 Monocerotis, for well did Herschel say, "It is one of the most beautiful sights in the heavens."

Always within reach is Burnham's "1290;" how nearly perfect are his measures, and hopeless the attempt to equal their precision. The book is a classic in astronomy. The Moon is white, not yellow, while the Sun reveals a complexity of surface structure with clearly seen granulations.

The Inclined Railway.

Neither Suphis the monarch of Egypt, nor Rameses II, nor the builders of Nineveh, did greater work. Engineers from every nation on Earth have studied this wondrous electric road from Pasadena to the base of Mount Lowe (altitude of end of line line 5,000 feet) and have pronounced it one of the chief monuments reared by human hands.

The incline here shown (Plate IX) is in length 3,000 feet, with vertical ascent of 1325 feet, and grades of 45, 48, 55, and 62 per cent.

Bridge MacPherson, spanning a chasm, is in length 200 feet with ascent of 100 feet, and named in honor of its builder. Two white chariots—like winged cars in space—chariots that have carried more distinguished visitors than those of Rome, balance on an endless steel wire cable, the car Rubio being down while Echo is at the top, invisible owing to curvature of road bed. Three rails carrying two cars which pass at the switch half way up. The ponderous machinery is at the top and is actuated by electricity from the Santa Ana river 90 miles away. The current comes to Pasadena on three wires at a pressure of 33,000 volts with 50 cycles. Here it is stepped to 2,200 volts and sent to the power house on Echo mountain, where its potential is again lowered to the usual railway pressure, and made direct by a G. E. C. 20 ampere induction motor. In case this supply should fail, there are dynamos in the building on the left turned by two Pelton wheels, run by water from a reservoir near the Observatory, 1,500 feet above. The pressure is terrific and

PLATE X.

THE GRAND VIEW FROM MOUNT LOWE OBSERVATORY.

(See page 363 for places designated by numbers.)

the water struggles to escape its narrow prison, the half inch nozzle. Should this source fail also, there are dynamos and gas engines on the mountain top, and these are used when Los Angeles and Pasadena are taking all the long transmission current.

The average distance of the sea from the Observatory is 30 miles, the section cut out by the peaks on the west (right) to the southeast is 120°, the land area being therefore 900 square miles. It is the garden, the flower bed of the world. It will contain the homes of 2,000,000 human beings in the not distant future.

On Plate X the numbers are:

1.	San Nicholas Island, distance from Observatory	110 miles.
2.	Santa Barbara " " " "	70 "
3.	Santa Catilina " " " "	65 "
4.	San Clemente " " " "	97 "
5.	Port Los Angeles, " " "	26 "
6.	Santa Monica, " " "	27 "
7.	Hermosa Beach, " " "	27 "
8.	Redondo, " " "	28 "
9.	Point Fermin, " " "	35 "
10.	San Pedro and Government Pier, distance from Observatory	33 "
11.	Dead Man's Island, " " "	34 "
12.	Long Beach and Los Alimitos, " " "	32 "
13.	Newport, " " "	40 "
14.	To Mission de los Capistrano and San Diego,	
15.	Pasadena, distance " "	6 "
16.	San Rafael Hills, " " "	4 "
17.	Verdugo and Tujunga Mountains, " " "	8 "
18.	La Canada Valley, " " "	6 "
19.	San Fernando Valley, " " "	25 "
20.	San Gabriel Valley, eastward, " " "	60 "
21.	The Observatory.	
22.	The Inclined Railroad, " " "	1 mile.
23.	Los Flores Canyon, " " "	2 miles.
24.	Car to Mount Lowe, " " "	3 "
25.	"Nuestra Senora la Reina de los Angeles," " "	14 "
	(Our Lady the Queen of the Angels).	

The Sierra Madres stand as a Herculean wall to guard the Elysian fields from the horrors of the Mojave desert, where Nature is at war against all forms of life, for here she conjures up the spirit of furnace winds and they issue forth on their paths of death. The fiery tempest gathers up sand in clouds and strives by every power to fling the flinty grains into the enchanted palaces of the flowers on the other side. The wrath of Mojave is frightful to behold; it seeks to hurl destruction in paradise and submerge the myriads of lilies, roses, carnations, spread in fields,

and heliotrope piled in banks along with magnolias, with flowering heaps of mosses, with trailing vines, with blooming century plants, and countless palms. It is against these that the fury of the desert is directed; it strives to destroy them all and crush them beneath silicious sheets. But old Madre's ramparts withstand the panting rage of the winds, the sand falls in tons and the home of the orange blossom is saved. An impalpable dust, however, comes over at times and this possesses peculiar spectroscopic properties. But the heated wind meets a foe more formidable than the mountains. It starts to destroy Los Angeles but meets a force able to subdue its blighting; the new enemy is the ocean wind. They meet on the summits, instant war rages round about the peaks—rushing currents hot and cool whirl around the crags and roar in the canyons. The field of war is forty miles wide and the conflict must be on until one side is hushed to silence. Old ocean wins; the mighty powers lifted up from the waste places of the sea, are more potent than those marshaled on the wilderness of sand. The torrid air is subdued, its tropic heat is tempered to the most perfect state on Earth. It is the climate of California. When the mountain battle is at its height and the Furies of the desert scream in impotent rage, it is all peace and calm at the Observatory; the towering bulwarks on the north hurl back the winds of death, and protect the vale below. To be in the war an ascent to Mount Lowe must be made, altitude 5,000 feet. Human life, or vegetable save that of the cactus series, could not exist on the vista, were it not for these struggles of the elements. A few days of blasts from the appalling Sahara just on the other side of the mountains would change a scene of terrestrial splendor to an expanse of blackened death. Heaped up flowers would collapse in a day, shriveled violets, fainting hyacinths, fading primroses and dying tulips could only make feeble effort to send out tinted rays or waning colors. Animals would flee in terror from the expiring land and man retire if Mojave could break down the wall of stone.

Los Angeles is a queen, the metropolis of the coming Empire of the Southwest; a city that without doubt is now growing more rapidly than any other in the world. Almost all the buildings can be seen from the Observatory, while Pasadena lies smothered in orange, lemon, olive, apricot, peach, walnut, almond, and eucalyptus trees all aranged in squares between roads as shown. What spot on Earth can equal the San Gabriel valley? Honey, figs, small fruits and every known species of grapes. Now the valley is illumined with countless peach blos-

PLATE XI.

NEAR VIEW OF MOUNT LOWE OBSERVATORY.

(See page 365.)

soms, then the almond burst into bloom, while from November to April the orange orchards contain blossoms enough to bedeck all the brides of the world. The Earth is yellow with oranges and lemons and in the height of the season in February the entire valley is a scene of activity, gathering and shipping the fruit. At night the cities blaze and glow in a luminous sea of electric lights, while the great resorts on the beach send in their rays from the ocean's shore to help frame this picture, this unparalleled work of nature and art. To add to the wonders of the scene the immense search light at the top of the incline is turned into both cities; it flashes into the hotels, lights up the pavement along the streets, covers a field of oranges with glory, and when a steamer appears, the piercing beam is thrown on deck, startling the traveler at sea. Here is the home of the fairies and they may be imagined to emerge from the canyons, inaccessable recesses in the mountains and from caverns yet unexplored, to look upon the stupendous night display. To the left (east) of the Observatory is the beginning of Rubio canyon, the house at the base of the inclined railway being near the end. Its depth under the Observatory is 670 feet, and still to the left is seen the almost vertical wall of granite rising 600 feet above the base of the dome, forming along its ragged crests the entire eastern horizon. Thus, the stars can be seen at the precise moment of rising, and the Sun is caught by the slit of the spectroscope even when the upper limb is not more than 10′ above the rock. The Observatory is standing on Echo mountain and near the hotel is a cannon. When this is fired, old Rubio's silent depth is awakened, and she hurls back the thunders of Gettysburg and Chickamauga, and when revolvers are discharged the rattle of musketry is heard. A bugler sounded the calls of the army of the United States. The cyclopean rock-bound enclosure heard the alarm and many times repeated the call to war. Opera singers also come and strike their sounding notes, the listening caverns are abashed, and perplexed at harmonic tones,—being accustomed to the sounds of elemental conflicts—but soon they burst forth into song. The echoes are impressive and as remarkable as those of Kentucky's Mammoth Cave.

Plate XI gives a nearer view of Observatory, power houses, with an enlarged panorama of Pasadena, San Gabriel with its ancient mission, the towns of Garvanza, Altadena, Alhambra, Shorb, Ramona, Lamanda Park together with fields of oranges, lemons and apricots, olives and peaches, ostrich farms and the marvelous solar motor.

Fig. 2 of plate XII shows the enchanted vista, the Observatory, a scene on the electric railroad to Mount Lowe, with the circular bridge, winding tracks and a car ascending. Mount Santiago is looming up in the distant southeast (40 miles) with the world renowned Puente hills (14 miles) slightly to the right. Fabulous wealth in petroleum is stored under the entire hill, derricks rise everywhere and the drill seldom stops, while fires of burning natural gas never expire.

To secure Fig. 2 the camera was set on a peak to the northwest. Far to the left the ancient ocean floor, now the home of the orange, extends to Riverside, 52 miles, to Colton, Redlands and San Bernardino. Still further to the east is the pass of El Cajon through which the railroads emerge into the eastern Mojave desert.

East of Pasadena (Crown of the Valley) nestle the towns of Los Robles, Arcadia, Azusa, Ontario, Cucamonga, Etiwanda, Rosena and Rialto, almost invisible in groves of orange and lemon trees.

Cloud Effects.

In the rainy season clouds form and vanish rapidly. Cloud layers at times are even down to the top of the court house tower, at others their altitude may be anywhere up to 500, 800, 1000, 2000, 3000 feet, or up to the windows of the Observatory. When they reach the base of the dome, the telescope being horizontal, then with low powers, an infinite number of crests of hills of cloud are seen glittering in white—the Sun lighting up the amazing scene with a brilliancy unknown on plains.

This place is ideal for the study of meteorology, thus when a storm is seen beginning on a peak, all processes of its evolution can be watched in an opera glass. And when one forms against the Observatory, every step in the condensation of invisible vapor first into thin mist, then heavier, and next to cloud and rain may be observed. It is entirely different being at the top, instead of at the bottom of a rain storm. The lowest barometer here was 26.80 and highest 27.43 inches. The effects of refraction are observed, ocean, plains, cities and hills are distorted, by bending rays, although mirage has not yet been seen. California is a land of wonders not yet explored—mysteries hover over its peaks and hide in the solitary canyons, where shades fall in caves of thundering winds.

The Observatory is in a wilderness of semi-tropic plants, some delicate in the extreme, scarcely able to call attention to their

PLATE XII.

CLOUD EFFECTS, FIG. 1.

MOUNTAIN VIEW AND RAILWAY TRACK NEAR THE OBSERVATORY.

(See page 366.)

faint perfume or feeble glories, while others are of sinister aspect, warlike, spiked and armed. Barbed cacti, of forbidding mien, the bayonet plant with projecting lances, and Yucca bristling with needles stand on all sides in formidable array—yet incredible to relate the gnarled and twisted stems are weary holding weights and loads of gorgeous flowers—expanding visions of color, vegetable spectra—whose velvet petals at times are torn by piercing spears and barbed hooks below, when the branches tire and bend under the heavy blooms. Nature sets up opposition and from the windows, throughout the year, incessant rivalry is seen, waged between humming birds and bees for the abundant honey. Geologists, entomologists, biologists, botanists, mineralogists, microscopists, meteorologists, students of the sea, mountain climbers, Sun worshipers, railway and electrical engineers, artists, photographers, explorers, spectroscopists, astronomers and all who love nature can enjoy this unequalled place.

VISIBILITY OF MERCURY.

G. SENECA JONES.

FOR POPULAR ASTRONOMY.

Watching the planet Mercury from my window this evening as it slowly sinks in its slanting path to the eastern horizon, I recall to mind an article on "Mercury as a Naked-Eye Object," written by Mr. W. F. Denning and reprinted from *Nature* in the April, 1900, number of this journal.

Mr. Denning's experience with Mercury has a special interest for American star-gazers as it illustrates strikingly the difficulties which beset the observation of this planet at European stations and particularly in England, in contrast with the ease with which it can be observed in the lower latitude of the United States. The more northerly English observer must contend, not only with a longer duration of twilight than is the case with us and a lower altitude of the planet, but also, as may be gathered from Mr. Denning's article, with a larger percentage of unfavorable weather.

On referring to his note book Mr. Denning finds that he obtained naked-eye views of Mercury on 102 occasions between February, 1868, and December, 1899; that is to say, he has recorded that number of views in the course of thirty one years, an average of three and one-half observations annually. He

adds, however, as a conclusion drawn from his experience, that if an observer with good sight made it a point to secure as many unassisted eye-observations of this object as possible, he might be successful on about twelve occasions in a year.

The great difficulty of obtaining a sight of this "elusive little Messenger of the Gods" is a theme familiar to every reader of astronomical books. The pathetic complaint, or regret, of Copernicus that at his home on the Vistula he had never once been able to see Mercury confronts us in nearly every article descriptive of this planet.* Proctor, in one of his books, not only expatiates on the exceeding great difficulty of obtaining naked-eye views of Mercury, but gives also a characteristic mathematical exposition of the reason therefor; and Flammarion, treating the same subject in his Popular Astronomy, says, as if to illustrate the rather fortunate situation of his own country in this regard: "In France there hardly passes a year without the planet's presence being verified once at least, and I, for my part, have made several observations," to which his transator, Mr. J. E. Gore, adds a note: "I have frequently seen it in Ireland with the naked eye."

Much of the popular astronomy of this country is derived from the books of European writers, and is it not surprising, therefore that the notion that Mercury is an exceedingly difficult naked-eye object should be prevalent here, as well as in Europe, at least among those whose astronomy is mostly of the book description. Yet every one who has taken a sufficient interest in the planet to look for it at those times when, as may be learned from any almanac, it should be visible, either as a morning or an evening star, must have discovered that its traditional shyness has been very greatly exaggerated, at least for observers in the mean latitude of the United States. Professor Newcomb, in his Popular Astronomy, speaks of the visibility of Mercury in a way calculated to correct this popular error. While the occasions on which the planet may be seen are very far from being equally favorable for observation—the best time for seeing it as an evening star is in the spring and early summer, since it is then on the north side of the equator, and as a morning star, in the autumn, for the same reason. Newcomb estimates the average duration

* Mr. Denning questions the strict accuracy of this oft-repeated story. At any rate, "there is evidence," he says, "to show that he (Copernicus) never expressed himself in the manner quoted in many of our popular text-books." He might have added that Copernicus was not an astronomer, in the sense in which Tycho Brahe and Kepler were astronomers, and very likely never made a persistent effort to see Mercury.

of its visibilty, either as a morning or an evening star, at about three weeks. From my own experience with the planet I think this estimate, made, presumably, with a reference to the latitude of Washington, a fair one. In the course of the year—or more exactly in a period of about eleven and a half months—Mercury appears three times as an evening and three times as a morning star. The six appearances together give the planet, upon this estimate, eighteen weeks of possible visibility out of the fifty weeks of its annual cycle. If we assume that two-thirds of the mornings or evenings of these eighteen weeks are cloudy or too hazy to permit the planet to be seen—which is certainly a liberal allowance of bad weather for most sections of this country—we still have left forty-two days on which observations of this object may be secured in the course of a year. As to the duration of its visibility on the more favorable occasions, the following extracts from my notebook will be more satisfactory than a mere general statement: "June 29, 1899. Saw Mercury with opera-glass at 7:55 P. M. (sunset at 7:32) and soon after with a naked eye. Superior conjunction, June 14. Could probably have been seen at least two days sooner but for hazy sky. . . . August 7. Saw Mercury again to-night with opera-glass and with difficulty with naked eye, very low. Eleven days before inferior conjunction." Between these entries are numerous others recording observations of the planet. The interval between the first and the last is 5 weeks 4 days. Unfortunately, I failed to make an entry of every observation and am unable to say on how many of these thirty-nine evenings I saw the planet; but I am sure I surpassed the best record of Mr. Denning, who says that the greatest number of naked-eye observations of Mercury obtained by him at the same elongation was at Bristol in the spring of 1876, when the planet was seen on thirteen different evenings.

The brilliancy of Mercury when at its brightest—about a month before and after its superior conjunction with the Sun—is, I think, usually under-estimated. Sufficient allowance is not made for the fact that the planet is always more or less involved in the twilight glow. Since the first part of this article was written (June 3), I have had three other excellent views of Mercury, now about at its brightest, and I have taken the occasions to make careful comparison between it and Capella. I find the planet unmistakably brighter than the star, considerably brighter. On each evening, after having carefully located the two objects with an opera-glass, I watched for their first appearance to the

unaided eye. On all three occasions I was able to make the planet out distinctly before I was quite sure I could see the star. Yet Mercury was always handicapped by a decidedly yellowish background, while Capella, farther north and three or four degrees higher, shone on a background of bluish sky. These observations convince me that the statement very commonly made in text-books that Mercury at its brightest may surpass a star of the first magnitude might be put even more strongly than this. The planet is now certainly above the zero magnitude, that of Capella being, according to the *American Ephemeris*, 0.1. That is to say, the planet is now (to my eye) two and a half or possibly three times as bright as a typical first magnitude star.

2136 Uber St., Philadelphia,

June 8, 1901.

NON-EUCLIDEAN GEOMETRY AND ASTRONOMY.

W. H. S. MONCK.

For Popular Astronomy.

I readily admit that I have not read much of the recent treatises on Non-Euclidean Geometry and if the question is of such little importance in astronomy as Professor Halsted confesses, I do not think I have sustained any great loss. If, however, Euclid's axioms were based merely on experience, I do not think he deserves any special credit because they are practically found to hold good far beyond the limits of his experience. Had Euclid any experience which would justify him in asserting that even as regards the nearest fixed star, α Centauri, his 180° for the sum of the three angles might not be erroneous to the amount of an entire degree? A lucky guess is a different thing from a far-reaching grasp of the subject. Personally, I am disposed to concur in the opinion of Kant and others that our knowledge of the properties of space is not dependent on experience but can be discerned by mental intuition, and I shall hold Euclid to be right—not approximately but accurately—until somebody proves him to be wrong. As to the discussion of the question by algebraic—or as it is called analytic—geometry, I lay no stress whatever on it because the very first step,—the representation of the line and the circle by algebraic formulæ—depends on the axioms of Euclid and cannot, I believe, be proved without their assistance.

Professor Halsted seems to admit that in the case of the farthest star whose parallax has hitherto been tried, the sum of the three angles cannot be greater or less than 180° by more than the hundredth part of a second. If so I think Non-Euclidean Geometry can have no practical result in astronomy for many years to come, if ever. But I do not know on what grounds he arrives at this conclusion. If Bolyai is right in believing that the sum of the three angles of triangles of enormous area is less than 180°—the defect increasing as the area increases—why may not α Centauri be not the nearest but the most distant of known stars, its apparent parallax of about 0″.75 being due to its great distance and the consequent large area of the triangle which we employ in our observations. If we once admit that the parallax of a star may be due not to its nearness but to its remoteness, our researches in that direction seem to me to be at an end. The Clifford and Riemann theory is free from this defect, but it has the opposite one that computation of parallax on Euclidean principles will always lead us to overestimate the relative parallax and thus diminish the computed distance of the nearer of the pair. If the NonEuclideans were agreed as to whether the effect of the departure from Euclid's axioms would be to increase or to diminish the parallax of a very distant star, we might have some test to appeal to. But if one Non-Euclidean says that the sum of the three angles is less than 180°, while another says that it is greater, it will be very difficult to refute both by any series of observations —more especially if the advocates of both theories keep their alleged variations within the limits of probable error in our observations.

I never saw the proofs (or alleged proofs) of Lobachevski and Bertrand referred to by Professor Halsted but am gratified to find that other persons arrived at the same results independently. The proof which Professor Halsted refers to Lobachevski was in fact my own limitation of that of Legendre which I did not think held good to the full extent. But I am a little puzzled at Professor Halsted quarreling with me, first for assuming that every right line can be produced to infinity, and secondly, for maintaining that as regards infinites the whole is greater than its part. Surely either we are dealing with infinites or we are not. If there is an end to space where our right line can proceed no farther or can only be produced by turning it into a bent line and perhaps ultimately bringing it home again, there is no infinite to be dealt with and the axiom that the whole is greater than its part can-

not be disputed. A great deal of nonsense has been written about infinity; but treating it as a real thing, the analogy of real things seem applicable. That $\frac{35\,(x-a)}{x-a} = 35$, seems to me to be true even when $x - a$ becomes zero or infinity. At all events there is nothing absurd or fallacious in supposing it to be so, and without reading the writings of the Non-Euclideans I think I may venture to say that on this subject of infinity they have not advanced much beyond the philosophers who have been writing on it for more than two thousand years, many of whose writings I have read without deriving any very great benefit therefrom. I commend in particular the discussions of Sir William Hamilton and Dean Mansel to the consideration of Professor Halsted and hope that if he reads them he will be as wise at the end as at the beginning. But for my own part I doubt if anybody has refuted anybody else where the subject in dispute was infinity. I cannot see that I have assumed the infinity of the right line nevertheless.

Can Professor Halsted point out any advantage that astronomy can derive from Non-Euclidean Geometry or any way in which the astronomer may hereafter hope to decide between the conflicting theories of Bolyai, Euclid and Clifford (or Riemann)? The Non-Euclidean can "make epochs" and amuse himself with his analysis for a lengthened period as long as he cuts down Euclid's possible error to the hundredth part of a second; while if our instruments become too accurate for him, he can reduce his error-limit. But in a physical science like astronomy, speculations which do not seem to be based on any experience nor observation are in my opinion quite out of place.

There never yet was a physical law which might not be safely challenged by a theorist who took care to keep his differences from the current theory within the possible limits of observational errors. But few practical men will attach any importance to these challenges unless some facts of observation can be cited in support of them. In the present instance I think one page of such facts would be worth 100 pages of mathematical computation based on mere assumptions; and when I find one computer concluding that the three angles of a triangle are greater than 180° and another that they are less—though the excess or defect may be infinitesimal—I am apt to think that they are weaving cobwebs out of their own brains and that their speculations can never assist the astronomer in determining the true distances and positions of the stars.

AN ERROR IN THE AMERICAN EPHEMERIS.

WILLIAM H. PICKERING.

FOR POPULAR ASTRONOMY.

On the evening of July 23 I was measuring the ellipticities of Jupiter's satellites with our 5-inch telescope at Mandeville, Jamaica. Satellites I and II were in conjunction following the planet, and the former was near its round phase. When the ellipticity is slight I always make it a point after identifying the satellites in the telescope, to consult the *Ephemeris*, to make sure that my identification is correct. On this occasion I called the northernmost of the two satellites I. What was my surprise on consulting the *Ephemeris* to find it given as II. As I could not recollect ever having been mistaken before in the identification, and as I had never seen II so elongated, I was much interested in watching further developments. Soon it began to lengthen still further, in the manner so characteristic of I, reaching successively ellipticities of 1.04, 1.06, 1.08, 1.06, 1.07 and 1.09. My faith in the *Ephemeris* now began to waver, and I feared I had not made such an interesting observation after all, especially as the supposed I, persisted in retaining its original rounded form, without a sign of lengthening, even after an hour. I now returned to the *Ephemeris*, and found that while I had just transited the planet, II was on its way to be occulted. They were therefore moving in opposite directions, and as when first seen they were in conjunction, while now they were well separated, it was easy to see that after all the *Ephemeris* was wrong, that the elliptical satellite was I, and that it was simply behaving just as it ought to do. It was now noticed also that the *Ephemeris* placed IV on the wrong side of the planet, so that it was wrong in two respects.

The seeing in Jamaica is very good indeed during the summer months, perhaps equal to that at Arequipa, but I had scarcely expected to be able to use the 5-inch telescope for work. On reducing the aperture to four inches, the ellipticity of I could still be observed, but with three inches it could no longer be detected, that is to say, with this aperture I and II appeared as nearly as I could judge of the same shape. This observation interested me, for never in Cambridge with the 15-inch, have I been able to see a well defined disk to either I or II. The disk of III, I have sometimes seen, but never as well as the same is shown here with a 4-inch aperture. In other words, *when there is plenty of light*, a 4-inch telescope will show an object to better advantage in

Jamaica than a 15-inch, or a 40-inch for that matter, will do it in Cambridge. Indeed, where there is plenty of light, as for instance on the Moon, little is gained at home by the use of a large aperture, and for photographic work. I have found that better definition is secured with four inches than with eleven.

It may interest the readers of POPULAR ASTRONOMY to know that satellite III has now entered upon one of its very elliptical phases. These phases are very rare, and their period is unknown. We cannot therefore tell how long the phenomenon will last, but when well marked it should be seen even at northern stations. On July 22 its ellipticity reached 1.09 to 1.10, and its position angle was 170°. Three days earlier, on the other side of the planet, the ellipticity was about the same, but the position angle was not far from 90°. Owing to haze and a high wind accurate measurements were not possible. The period of the change in position angle is the same as that of the satellite about its primary. In passing from one position angle to the other the disk assumes a circular form. To observe this phenomenon in the states, I should recommend an aperture of four or five inches, and a magnification of about three hundred diameters.

MANDEVILLE, Jamaica, W. I.,
July 24, 1901.

GEORGE K. LAWTON.

T. J. J. SEE.

FOR POPULAR ASTRONOMY.

In the unexpected death of George K. Lawton, of the U. S. Naval Observatory, a young astronomer of great promise has passed away. The loss to American astronomy can be appreciated as yet only by those who had the good fortune to know him intimately. He was born Oct. 20, 1873 and died at Washington July 25, 1901, after a brief illness of twelve days, of typhoid fever; and was thus less than 28 years of age. Under the guidance of his father, Professor U. W. Lawton, of Jackson, Michigan, he had enjoyed from childhood excellent educational advantages, and in 1895 graduated in classics at the University of Michigan, where he also pursued advanced astronomical studdies under Professor Asaph Hall, Jr., at the Detroit Observatory. He then spent a year in post graduate study at the University of Chicago, where the writer had the honor to be one of his teachers. He showed distinguished abilities in the study of celestial

PLATE XIII.

GEORGE K. LAWTON,
1873-1901.

mechanics and of higher mathematics. He was afterwards attached to the Observatory of Yale University for a short time, occupied mainly with work on meteors; and then came to the Naval Observatory as one of the regular computers. In 1897 he took the degree of M. A. at the University of Michigan. While attached to this Observatory he participated in all the Transit Circle Observations of the past five years, much of which has recently appeared in the *Publications of the U. S. Naval Observatory, Vol. I., new series.* Last year he also bore an important part in the observations of the total eclipse of the Sun, at Pinehurst, North Carolina. More recently he took the leading part in the reductions and revision of the Eros observations of this Observatory, and has been occupied partly with equatorial work. Only a month ago he was permanently assigned to the 26-inch equatorial, and had entered upon researches of great promise.

On account of his extreme modesty, and the arrearages of our publications, his scientific reputation at the time of his death, was in no way commensurate with his merits. Yet he was already a member of the American Association for the Advancement of Science, and last year participated in the meeting of the Astronomical and Astrophysical Society of America.

His mind was developed in admirable symmetry and harmony, and his scholarship almost as good in Latin and Greek and general literature as in modern science. He had that happy faculty of cool, quiet judgement, combined with good nature, which made him adequate to any occasion. Besides possessing scientific and literary talents of a high order, he was of a very high minded and noble disposition, universally beloved by his associates. Unseen by men he did continually many acts of benevolence, and bestowed gracious remembrances which add to the charm of life, and make us realize that the high types written of long ago have not wholly passed away. He was an active member of St. Thomas's church in this city and of the Brotherhood of St. Andrew, and of the Alumni Association of the University of Michigan. During his residence here for five years, he became fairly well known in the city, more by the reputation of his high character than by any very extensive mingling with the people. When the writer had to send the saddest of messages to his grief-striken family, the telegraph operator who knew him only by reputation, was nearly overcome, and said "that good man is not long for this world."

In all my experience I have never met quite so modest, so noble

and so loving a character. He belonged to that group of high types, of whom Pope has written in his Temple of Fame:

> Then came the smallest tribe I had yet seen;
> Plain was their dress, and modest was their mein.
> Great idol of mankind! we neither claim
> The praise of merit, nor aspire to fame!
> But safe in deserts from the applause of men,
> Would die unheard of as we lived unseen.
> 'Tis all we beg thee, to conceal from sight
> Those acts of goodness, which themselves requite.
> Oh let us still the secret joy partake,
> To follow virtue e'en for virtue's sake.
> And live there men, who slight immortal fame?
> Who then with incense shall adore our name?
> But mortals! know, 'tis still our greatest pride
> To blaze those virtues, which the good would hide.
> Rise! muses, rise! add all your tuneful breath,
> These must not sleep in darkness and in death.
> She said: in air the trembling music floats,
> And on the wind triumphant swell the notes:
> So soft, though high, so loud, and yet so clear,
> E'en listening angels lean'd from heaven to hear:
> To fartherest shores the ambrosial spirit flies,
> Sweet to the world, and grateful to the skies.

The sudden death of Mr. Lawton, almost at the very beginning of what promised to be a brilliant career, has cast a deep gloom over the entire Observatory. He was indeed the noblest of the noble, and his place can never be filled.

WASHINGTON, D. C., 1901, July 27.

ON THE ECLIPSE PREDICTED BY THALES.

JOHN N. STOCKWELL.

FOR POPULAR ASTRONOMY.

In No. 70 of this journal Professor R. W. McFarland has given a very interesting paper on the subject of Ancient Eclipses and Chronology which had been previously read at the Columbus meeting of the American Association for the Advancement of Science; and in No. 84 of this journal he has further considered the same subject and fortified the conclusions of his first paper, by extending the limits of time between which the eclipse of Thales must have happened from forty-six to eighty-six years, and increasing the number of dates which have been assigned to that eclipse from nine to twelve; all of which are equally probable. His final conclusion is that the records of ancient eclipses which have been preserved to our time are absolutely worthless in fixing the dates of ancient events.

The object of this paper is to show that Professor McFarland's conclusions as to the value of the records of ancient eclipses in fixing ancient dates are not valid; and also to show that the limits of time between which the eclipse of Thales must have happened may be greatly reduced, if not wholly removed.

Professor McFarland bases his reasoning on the following principles as laid down by Sir John Herschel in his outlines of Astronomy: "It is fortunate for astronomy that the confusion of dates and the irreconcilable contradictions which historical statements too often exhibit, when confronted with the best knowledge we possess of the ancient reckonings of time, affect recorded observations but little. An astronomical observation, of any striking and well marked phenomenon, carries with it, in most cases, abundant means of recovering its own date; when any tolerable approximation is afforded to it by chronological records; *and, so far from being abjectly dependent on the obscure and often contradictory dates, which the comparison of ancient authorities indicates, is often itself the surest and most convincing evidence on which a chronological epoch can be brought to rest.* Remarkable eclipses, for instance, now that the lunar theory is thoroughly understood, can be calculated back for several thousands of years, without the possibility of mistaking the day of their occurrence. And, whenever any such eclipse is so interwoven with the account given by an ancient author of some historical event, as to indicate precisely the interval of time between the eclipse and the event, and at the same time completely to identify the eclipse, that date is recovered and fixed forever."

This is what Professor McFarland calls Herschel's criterion; although he does not attempt to apply it to the determination of the date of the eclipse of Thales. The principle is not new; and it has been applied with more or less success during the past three hundred years.

The above criterion assumes that we are able to calculate not only the date of any eclipses which may have occurred in past ages, but also the exact time and circumstances under which they occurred at any given place. This extension and limitation of the powers of the criterion, together with a properly described eclipse at a given place, affords all the needful data for determining its date; for it may safely be said that no two eclipses ever occur at the same place under precisely the same local circumstances.

Professor McFarland attributes the existence of so many dates

for the eclipse of Thales to the faults of the historian, for he distinctly says that it is not at all the fault of the astronomer. The earliest authors cited are Cicero and Pliny, who place it in the fourth year of the forty-eighth Olympiad; which corresponds to the year 585 B. C. Neither Pliny nor Cicero were astronomers, nor were they discussing a question of chronology; and they simply alluded to the eclipse of Thales as illustrating the ability of astronomers to calculate them, and for no other purpose.

Next come Scaliger and Usher, who lived some three hundred years ago and before there was any lunar theory in existence; and Professor McFarland will hardly contend that the circumstances attending a solar eclipse, such as the time of day when it occurred, and its magnitude at a given place on the Earth's surface could have been accurately predicted by Cicero or Pliny, or by Scaliger or Usher, or in fact by anybody before the beginning of the nineteenth century. It is true that Pingre's tables of eclipses had been computed before that time; but they amounted to little more than a table of dates of eclipses and gave no accurate information as to the circumstances attending them. In fact it cannot be truly said that there was such a thing as a lunar theory in existence before the beginning of the nineteenth century; although it is true that LaPlace had discovered the Moon's secular equations a little before that date; but they had not been incorporated into the lunar tables and applied to the calculation of ancient eclipses. We may therefore reject as worthless all calculations concerning the eclipse of Thales which were made before the year 1811, when Sir Francis Baily applied the modern theory of the Moon's motion to its investigation.

Now, one element of Herschel's criterion is a knowledge of the approximate date of the eclipse. This element is entirely omitted in the description of the event by Herodotus; but in this case it does not matter, for a knowledge of the time when Thales lived supplies sufficiently the missing datum.

Classical historians inform us that Thales was born about the year 640 B. C.; and Anthon tells us that he died at the age of ninety years. I am not aware of any controversy as to the time when he lived; and we may safely assume that the eclipse predicted by him occurred between the years 640 and 550 B. C. From purely historical considerations Baily concluded that the eclipse must have happened between the years 629 and 595 B. C.; and by computing all the eclipses which happened during that period he found only one which was total in Asia Minor; and that took place 610 B. C., September 30:—a date which was

generally accepted as correct for more than forty years, or until Sir George Airy went over the same calculations in the year 1853. It should be remarked in this place that Baily admitted that his calculations concerning this eclipse were worthless, because he found that when the same lunar tables were applied to the calculation of another ancient eclipse, that of Agathocles, whose date was known, they completely failed to produce an eclipse such as was described by the historian.

After these researches by Baily, nothing more was done concerning the date of that eclipse for a period of forty years; and in the meantime new tables of the Moon's motion had been computed by Hansen, which were supposed to be greatly superior to those previously in use. These new tables were then employed by Mr. Airy as a basis for a new investigation of the eclipse of Thales. After first adjusting them so they would represent fairly well the eclipse of Agathocles he applied them to the computation of the eclipse of 610 B. C., and found that the Moon's shadow passed to the north of the sea of Azov, instead of passing through the northern part of Asia Minor as found by Baily. The eclipse of 610 B. C. could not therefore be longer considered as the eclipse of Thales; and in order to find an eclipse that would be total in Asia Minor it was necessary to extend his search ten years beyond the limit fixed by Baily from purely historical considerations. And this is the reason why he fixed upon the eclipse of May 28, 585 B. C. as the one predicted by Thales.

Professor McFarland does not hesitate to award the palm of merit to the investigations of Airy and Baily in their efforts to determine the date of that eclipse.

The only other persons who have given much attention to the subject of ancient eclipses during the last half century, so far as I am aware, are Professor Simon Newcomb and Professor McFarland; the former devoting eight pages of his "*Researches on the Motion of the Moon*," to the discussion of ancient eclipses or rather, to the discussion of the narratives concerning them; while the latter has devoted as many pages of this journal to the same subject. The purpose for which their investigations were made, however, were entirely different. Professor Newcomb was seeking data from the ancient eclipses for the rectification of astronomy; while Professor McFarland was seeking data from the some source for the rectification of chronology. The efforts of both these gentlemen resulted in dismal failure, both declaring that the historical narratives concerning the eclipses were too vague and indefinite to be deserving of serious attention.

In so far as the eclipse of Thales is concerned Professor Newcomb's account consists of a labored effort to prove that there was no eclipse at all; and if there was an eclipse it could not have been predicted by Thales. In a later investigation Professor Newcomb computed the eclipse of B. C. 585, May 28, and found that it ended at sunset in the southeast corner of the Mediterranean sea, and was nowhere total in Asia Minor.

I have now given, without serious omission, a brief account of the labors of astronomers and classical scholars on the interesting subject of ancient eclipses, in so far as they have been published to the world; and it now remains for me to give an account of my own researches on the same subject.

Professor McFarland, as I have already stated, asserts that the existence of so many dates for the eclipse of Thales is *not* the fault of the astronomer, but lies with the historian. I shall take an opposite view of the question and endeavor to show that the fault lies *wholly* with the astronomer, and as an introduction to this part of my subject I cannot do better than to quote an extract from a letter of the late Dr. B. A. Gould, whose memory I sacredly cherish as the great promoter of astronomy in the United States, as well as for his warm personal friendship and correspondence continued through nearly half a century, and which was interrupted only by death. On his return to this country from Cordoba in the Argentine Republic in 1880, he visited me at my home in Cleveland, and we discussed the lunar theory with considerable detail. He afterwards returned to Cordoba by way of London, and after his arrival there he wrote me as follows, under the date of 1881, Jan. 26:

"Since leaving Cleveland I have thought a good deal about your lunar work; and all the more since passing the 9th December at Greenwich and talking a great deal about the matter with the Astronomer Royal.

"He is naturally extremely conservative, first because it is his nature, secondly, because he is an old gentleman, who will be eighty in a few months; but thirdly, and most of all, because he is an Englishman through and through.

"Seeing is believing with them, and it is not sufficient to provide them arguments but the evidence must be administered to them with a ramrod.

"On my voyage I tried repeatedly to write you, but the motion of the ship, the various discomforts, and the ungenial surroundings are most unfavorable to any sedentary occupation; and as for writing anything not absolutely necessary, it is out of

the question. I had to give it up every time. But what I wanted to say is this, which I leave my star reductions to say to you now:—that I hope you will keep on and make the additional struggle which is necessary to give numerical demonstration to your results. Sir George Airy concedes that the present condition of the lunar theory is inadequate to explaining the old eclipses. Now all modern observations have been sufficiently compared with the various tables, Hansen's, Leverrier's, Plana's, etc., and the effect of the modifications proposed by others is in general known.

"Now if you can provide the time and labor which are necessary for comparing the Moon's place with any one of the modern tables for any convenient date in the present century; and also for any convenient date near the time of the old eclipses,—that of Thales, or Larissa, or Agathocles, or any other which has been worked up by recent astronomers, you will thereby be enabled to test your results in the most satisfactory and convincing manner. And if they come out satisfactory, as I am persuaded they will, your triumph will be complete.

"This test, great as the toil is which it implies, is the only one which will be accepted, and if successful will afford you higher rewards than you have ever hoped. And if you select say three or at most four widely different epochs for which the positions from any existing tables are known, you can, with a minimum of labor settle the question.

"Should you not feel equal to the work of grappling with the problem in this way, then by taking the one most convenient of the ancient eclipses worked up by recent astronomers, and showing that your lunar theory will at least meet that case, you will have done a great deal to insure for your results the reception and acceptance they deserve.

"Without some such demonstration, I doubt whether the archangel Gabriel and Galileo in partnership would be able to overcome the conservatism which exists on the subject:"

From this letter we learn that Mr. Airy frankly admitted that existing lunar theories completely failed to explain the old eclipses; a fact which was both previously and subsequently made known through his published investigations, since he devoted many years of the latter part of his life to a vain endeavor to improve them, and greatly lamented that his efforts were unsuccessful.

We may therefore sum up the astronomical argument in regard to the eclipse of Thales, as it stood in the year 1890, as follows:

In 1811 Sir Francis Baily by using the best lunar tables of his time computed that the Moon's shadow passed over the northern part of Asia Minor at the time of the eclipse B. C. 610 September 30; but he expressed a doubt as to the correctness of his conclusions since the same tables failed to give the eclipse of Agathocles, whose date was known.

In 1853 Sir George B. Airy by means of lunar tables which were supposed to be much more correct than those used by Baily found that the Moon's shadow in the eclipse of B. C. 610, Sept. 30, did not pass through Asia Minor at all, but passed even to the north of the sea of Azov. He also found that on May 28, B. C. 585 the Moon's shadow passed through the southern part of Asia Minor a little before sunset, and he therefore called that the eclipse of Thales.

Twenty-five years later, or in 1878, Professor Simon Newcomb by means of lunar tables which were supposed to be even better than those used by Airy, computed that the Moon's shadow in the eclipse of May 28, 585 B. C., left the Earth at sunset near the southeast corner of the Mediterranean Sea, and was nowhere total in Asia Minor.

It would therefore seem to follow from the calculations of these three astronomers, (Baily, Airy and Newcomb), that there is no astronomical evidence of any eclipse of Thales.

It was several years after my interview with Dr. Gould before I was able to carry out his suggestions; but in the meantime I had continued my investigations in the lunar theory and satisfied myself that LaPlace's value of the secular variation of the Moon's mean motion and of the motion of the perigee were very greatly erroneous. I therefore constructed new eclipse-formulas embodying my own values of the secular variation of the elements of the Moon's orbit, and proceeded to compute some well known eclipses.

The first was an eclipse of the Sun of comparatively recent date which was total at London. It occurred March 20, A. D. 1140. Mr. Hind by means of Hansen's tables finds that the southern limit of the Moon's shadow passed about fifty-five miles to the north of London, while my computations show that the southern limlt of shadow passed fifteen miles to the south of London, thus showing that it was total at London, as it was known to be according to observation. This eclipse, however, was too recent to be of much value as a test of the correctness of my value of the Moon's acceleration. As a second eclipse I took that of Agathocles, which occurred B. C. 310, Sept. 15, and was total

near Sicily. That eclipse took place so long ago that it would have thrown valuable light on the question of the Moon's secular acceleration, had it been properly observed and recorded. But the records do not inform us as to the *time of day* at which it occurred; and since the Moon's shadow followed very nearly a parallel of latitude, the circumstances attending the eclipse would have been very nearly the same at Sicily, with two widely different values of the secular acceleration of the mean motion. For instance, suppose we make the calculation of the path of the eclipse by using two values of the secular acceleration, one of which gives the Moon's longitude one-half of a degree different from the other; the time of the Moon's conjunction with the Sun would differ by about one hour, and the places of beginning and ending of the eclipse in the two cases would differ by nearly fifteen degrees of longitude on the Earth, while the intermediate portion of the shadow-path would be nearly the same for both. But the case is very different when the shadow-path makes a large angle with the parallels of latitude. In the supposed case the places of central eclipse at noon would differ by about fifteen degrees of longitude and the shadow-paths would be nearly parallel, but widely separated on the Earth's surface throughout their whole extent. In this second case it is not so important that the time of day should be known, the simple fact that the shadow passed through a given point of the Earth's surface being sufficient to determine the acceleration.

As a third eclipse I calculated the one mentioned by Thucydides as having occurred during the first year of the Peloponnesian War which took place B. C. 431, August 3. In this case the place of observation was Athens, and the eclipse was so nearly total that stars, or planets were visible. Astronomers have never been able to find an eclipse for that date and place, of sufficient magnitude for stars to become visible, and hence some chronologists have been inclined to doubt the correctness of the accepted date of the beginning of that war. But my eclipse formulas show that the line of central eclipse passed within two hundred and fifty miles of Athens and that the magnitude of the eclipse at that place amounted to 0.922 of the Sun's diameter; whereas previous computers obtained only about 0.7 for its magnitude, and found that the path of central eclipse passed more than one thousand miles from Athens. These three eclipses have received the very careful consideration of astronomers, at intervals, during the past three hundred years.

In addltion to these three celebrated eclipses I have computed

some twenty others of less note, which occurred between the years 763 B. C. and 878 A. D., and find that the computations in every case satisfy the narratives concerning them; and lastly I have determined the date of the celebrated eclipse recorded in the Chinese annals, and which occurred on the day of the autumnal equinox in the twenty-second century B. C. This is the earliest recorded eclipse, and it took place in the year 2136 B. C., Oct. 10, or more than *four thousand* years ago; and is the only one that has ever occurred in China under similar conditions.

The period covered by my computations therefore embraces all recorded time; and we may place implicit confidence in formulas derived from purely theoretical considerations and which stand the rigid test to which they have been subjected. Instead of confining my attention to three or four eclipses as suggested by Dr. Gould, on account of the great labor involved in the necessary computation, I have computed all the ancient solar eclipses that seemed to have any historical importance; and it seems to me that such eclipses afford the most trustworthy material for deciding controverted questions in chronology.

Having thus established the accuracy of my eclipse-formulas by means of a long series of ancient eclipses, whose dates were known, I shall now endeavor to determine the unknown date of the eclipse predicted by Thales; the account of which, as given by Herodotus, is as follows:

"After this (for Alyattes refused to deliver up the Scythians to Cyaxares when he demanded them) war lasted between the Lydians and the Medes for five years; during this period the Medes often defeated the Lydians, and often the Lydians defeated the Medes; and during this time they had a kind of nocturnal engagement. In the sixth year when they were carrying on war with nearly equal success, on occasion of an engagement, it happened that in the heat of the battle day was suddenly turned into night. This change of the day Thales the Milesian had foretold to the Ionians, fixing beforehand this year as the very period in which the change actually took place. The Lydians and Medes seeing night succeeding in the place of day desisted from fighting, and both showed a great anxiety to make peace." Herod. I, 74, as translated by Cary.

This is the whole history of the event; and if total eclipses of the Sun were of very frequent occurrence at any given place on the Earth's surface, the description would be entirely too vague to establish any definite conclusion concerning its date. The locality at which the battle was fought is subject to some uncer-

tainty, but it is known within narrower limits than the date of its occurrence. We may very properly suppose that it took place somewhere in the western half of Asia Minor, and occurred sometime between the years 550 B. C. and 700 B. C.; an interval of time which must have included the whole life of Thales.

According to classical scholars, Thales was born in the year 640 B. C. and lived to the great age of ninety years; the eclipse must therefore have happened *before* the year 550 B. C. Baily, for purely historical reasons, which seem to be plausible, found the limits of time between which the eclipse must have taken place were the years 595 B. C. and 629 B. C. But in my search for a total eclipse of the Sun which passed over Asia Minor I have not restricted my computations to such narrow limits, but have computed all that occurrred during the two hundred years preceding the year 550 B. C.; and found only *two* that passed over any part of Asia Minor; and these occurred in the years 610 B. C. Sept. 30, and 603 B. C. May 18; both being within the historical limits assigned by Baily.

It follows from this that the number of possible eclipses which may, or rather have been assigned for that event is reduced from *nine* to *two*; and the interval of uncertainty is reduced from *forty-six* to *seven* years.

The circumstances attending these two eclipses are so nearly similar that a more detailed description seems necessary. The eclipse of Sept. 30 occurred on the day of the autumnal equinox; and the southern limit of the Moon's shadow passed through Constantinople (*the ancient Byzantium*) and the extreme northeastern points of the gulf of Issus. The shadow was about one hundred miles in breadth, and it passed over central Asia Minor at exactly noon. In the eclipse of May 18, 603 B. C. the central line of the Moon's shadow passed from the western coast of the Isle of Rhodes on the southwestern coast of Asia Minor, to the mouth of the river Kizil Ermak (*the ancient Halys*) which flows into the Black Sea. The shadow was more than two hundred miles in breadth; and it passed over central Asia Minor at ten minutes before noon. The duration of total eclipse along the central line must have exceeded seven minutes; whereas in the preceding eclipse it could not have exceeded more than half that length of time.

From these descriptions it follows that there was about 20000 square miles of territory in central Asia Minor, which was common to the two eclipses; and if the battle took place within that territory, the problem would seem to be indeterminate from

purely astronomical considerations. If the place of the battle field were known, and found to be outside of this common territory, all the present difficulties of the problem would vanish. But on account of our ignorance of the location of the battle field, we are obliged to resort to other considerations in order to get a probable solution of the question as to which of these two eclipses put a stop to the battle.

The account of the eclipse by Herodotus informs us that it was predicted by Thales; and we have already seen that Thales was born in the year 640 B. C. In the year 636 B. C. there was a small eclipse of the Sun; and in 635 B. C. there was an annular eclipse nearly total at Miletus, the birthplace of Thales, who was then not more than five years of age. Had Thales witnessed them at that age it is hardly probable that he would have acquired any astronomical inspiration from them. After that, there were no eclipses of the Sun visible in that part of the world for a period of twenty-five years; when the total eclipse of September 30, 610 B. C. suddenly swept over the country at midday. Thales was then thirty years of age; and although the eclipse was not total at Miletus it was a very large one, and the magnificent spectacle must have created an enthusiastic desire to know more in regard to their causes and the laws which regulate their recurrence. It is therefore hardly probable that he predicted the eclipse of 610 B. C.; but that event was doubtless an incentive to the study of astronomy, and especially to a study of the motions of the Moon.

Thales is said to have been well acquainted with the motions of the Sun and Moon; but at what age he acquired that knowledge we have no means of knowing. We cannot properly suppose that he acquired very much of it before he was thirty years of age. Had he known of the Chaldean period of eclipses called the Saros it would hardly have helped him to predict the one which followed that of September 30, 610 B. C., unless he had a complete list of all that had occurred during the preceding Saros, or period of 18 years and 10 days. But if he had a correct knowledge of the motions of the Sun and Moon it would have been very easy for him to discover shorter and better eclipse periods than the Saros affords; as I will now proceed to show.

In a lunation the line of conjunction of the Sun and Moon advances in longitudes 29°.1056168, while during the same period of time the Moon's node retrogrades 1°.5648726; therefore in *eighty-two* lunations the line of conjunction will have advanced by 226°.66, and the place of the node will have advanced

231°.68. From this it follows that if the line of conjunction is at the node at the time of an eclipse, at the end of *eighty-two* lunations it will be only 5° distant from the *same node* and another eclipse will take place.

But a far more exact eclipse period consists of eighty-eight lunations; for in eighty-eight lunations the line of conjunction advances by 41.°294, while the line of nodes advances by 222.°291. The difference of these numbers is 180°.995; from which it follows that if the conjunction takes place at one node, at the end of eighty-eight lunations the conjunction will take place within 1° of the *opposite node*, and another eclipse will follow. Therefore if we have a list of all the eclipses which take place during a period of *eighty-eight lunations* we may readily compute the times of all that precede or follow, without danger of overlooking any unless they occur so extremely near the ecliptic limits that they become insignificant. These eclipse-periods are believed to be new: and they are far more convenient than the Chaldean Saros.

We have no means of knowing to what extent Thales was able to calculate the true place of the Moon at any time; but there is no reason to doubt his ability to predict the time of *mean* new Moon, although it *might* differ from the time of *true* new Moon by half a day, more or less. Now if the equations which affect the motions of the Sun and Moon happened to be small at the time of *mean* new Moon the time of *true* new Moon would differ but little from that of *mean* new Moon; and it would have been an easy matter for Thales to determine whether at the time of *mean* new Moon in any case the Sun was *above* or *below* the horizon.

If we apply this reasoning to the two eclipses under consideration we shall find

Time of mean new Moon in Asia Minor, Sept. 30, B. C. 610 was $7^h\ 40^m$ P. M.
" " " " " " " " May 18, B. C. 603 was $8^h\ 30^m$ A. M.

Now since the Sun was at the equinox on Sept. 30, it must have set at six o'clock; the time of mean new Moon therefore occurred one hour and forty minutes *after* sunset. On the other hand on May 18 the Sun must have risen at about five o'clock; and the time of mean new Moon was at the middle of the forenoon. It is therefore *not* probable that he would have predicted the eclipse of 610 B. C. unless he had the means of knowing how much the time of *true* new Moon would differ from that of *mean* new Moon, which we have assumed that he did not have.

Now if we suppose that Thales observed the eclipse of 610 B. C. it would afford him valuable data for the determination of any which might follow. If we add to the elements of that eclipse the changes which they undergo during eighty-two lunations we shall have the elements of the eclipse of May 18, 603 B. C., which took place just eighty-two lunations after that of 610 B. C. Therefore if Thales really possessed the astronomical knowledge ascribed to him there is no good reason why he might not have predicted the eclipse of 603 B. C., May 18; but his prediction would be subject to a large element of uncertainty for the reasons already mentioned.

Professor McFarland mentions nine different dates for the eclipse, scattered over forty-six years of time; and he reasons about the matter as if they were all visible at the same place and satisfied equally well the narrative of the historian concerning them. It is therefore no wonder that he thought the description too vague to identify the particular eclipse he was in search of. And this reminds me of a remark once made by Delambre, "that if we permit ourselves to deviate from the assigned date of an eclipse to the extent of *four years*, either earlier or later, we are almost certain to find one nearly corresponding in its conditions with that which was given;" which would imply that eclipses were of too frequent occurrence to be of any use. But these investigations show how utterly ignorant Delambre must have been on that subject; for our search has extended over a period of *two hundred years* and only *two* eclipses have been found in that interval, which bear any similarity to each other and to the one described by the historian.

Professor McFarland seems to agree with the French critic, Mr. Martin, that Thales never tried his luck at predicting eclipses again in the same way; but I do not regard that argument as possessing any weight; for eclipses of the Sun are not of such a nature that they can be predicted and verified at the pleasure of the computer; but it would seem to be a fact that he predicted the only one that occurred during his life time after having witnessed one.

Eclipses of the Sun of a given character at any given place are among the rarest phenomena of nature, and are of priceless value in determining questions of chronology, because a properly described solar eclipse affords the means of determining its own date.

We conclude therefore from this discussion, that the eclipse predicted by Thales took place on the *eighteenth day of May in*

the year 603 B. C.; and that the war between the Medes and Lydians terminated at noon of the same day.

CLEVELAND, June 7, 1901.

NOTE I.—It is usual to associate the names of *Cicero* and *Pliny* as concurring in the belief that the eclipse predicted by Thales took place in the *fourth year* of the *forty-eighth* Olympiad; but since the preparation of the above article I have examided the writings of Cicero, and find that he gives *no date whatever* for the eclipse. He merely says that it occurred during the reign of Astyages.

NOTE II.—Cicero in chapter 16 of the *Commonwealth*, after stating that Thales was the first to predict eclipses, and that Ennius afterwards became acquainted with his theory of such phenomena, discourses learnedly on the subject of eclipses in the course of which he says: "The calculations in the astronomical art have attained such perfection that from that day, thus described to us by Ennius, the anterior eclipses of the Sun have been computed and recorded in the pontifical registers as far back as the nones of July in the reign of Romulus, when that eclipse took place, in the obscurity of which it was affirmed that Virtue bore Romulus to heaven in spite of the perishable nature which carried him off by the common fate of humanity." J. N. S.

ON INTERPOLATION.

R. T. A. INNES.

FOR POPULAR ASTRONOMY.

I should like to draw the attention of your readers to a most convenient method of interpolation which is used in the *Nautical Almanac* office. I am encouraged to do this because it receives no notice in Mr. Herbert L. Rice's useful treatise on the *Theory and Practice of Interpolation*. Should interpolation to 12ths be wanted, Mr. Rice recommends interpolation twice to halves and once to thirds (see p. 54 of his treatise). This method is certainly simple and accurate, but the long series of 1st, 2d, 3rd, and 4th differences which have to be freshly computed at each interpolation make the operation very long. Interpolation to 12ths is chiefly required in the computation of the Moon's hourly ephemeris. Monsieur Abel Souchon of the "Connaissance des Temps," in his treatise on the construction of astronomical ephemerides remarks that the hourly lunar ephemeris is computed by the ordinary methods of interpolation, from which it may be gathered that the English practice is not followed on the continent.

The *Nautical Almanac* method is explained in the introduction to a little publication entitled *Interpolation Tables* printed in 1857. The explanation is not very clear, indeed, it has been said that Professor J. C. Adams declared his inability to understand it, but this is probably a "yarn."

The method seems to have been devised by Mr. Woolhouse and Mr. Farley, but it was brought to perfection by Mr. Godward; these three gentlemen being formerly on the *Nautical Almanac* establishment. The word "perfection" is used intentionally. Mr. Godward's tables cover 22 pages of the *Nautical Almanac* size and type, viz.:

Interpolation to 12ths to 4th differences,		7 pages.
"	" 10ths " " "	6 "
"	" 8ths " " "	5 "
"	" 6ths " " "	4 "

and are so arranged that, after the ordinary differences have been found, no computation whatever, except algebraical addition, is required, and only one decimal beyond what is finally retained is used.

Newton's formula of interpolation is

$$F_n = F_0 + na_0 + \frac{n(n-1)}{2} b_0 + \frac{n(n-1)(n-2)}{6} c_0 + \frac{n(n-1)(n-2)(n-3)}{24} d_0 + \text{etc.} \quad \text{[Rice p. 43].}$$

If a_{-1}, b_{-1}, c_{-1}, etc., are the preceding differences (as given by Rice, p. 45) we can write

$$F_n = F_0 + na_{-1} + \frac{n(n+1)}{2} b_{-1} + \frac{n(n+1)(n-1)}{6} c_{-1} + \frac{n(n+1)(n-1)n-2)}{24} d_{-1} + \text{etc.}$$

an expression due to Woolhouse.

Let us now suppose that we have to interpolate to 12ths; and to abridge we suppress obvious suffixes and neglect the 3rd and higher differences for the moment as the principle to be followed in their case is the same. Then

$$F_{\frac{1}{12}} = F_0 + \frac{1}{12} a + \frac{13}{288} b$$

$$F_{\frac{2}{12}} = F_0 + \frac{2}{12} a + \frac{28}{288} b = F_{\frac{1}{12}} + \frac{1}{12} a + \frac{13+2}{288} b$$

$$F_{\frac{3}{12}} = F_0 + \frac{3}{12} a + \frac{45}{288} b = F_{\frac{2}{12}} + \frac{1}{12} a + \frac{15+2}{288} b$$

$$F_{\frac{4}{12}} = F_0 + \frac{4}{12} a + \frac{64}{288} b = F_{\frac{3}{12}} + \frac{1}{12} a + \frac{17+2}{288} b$$

etc. etc.

The principle is obvious; to the last found F we have each time to add $\frac{a}{12}$ and the *b difference* increased by $\frac{2}{13} \times \frac{1}{288} b$.

It is plain that to evade the use of more than one extra decimal that no precaution is required so far as a is concerned; thus if we intend to retain as our unit 0″.1, we compute $\frac{a}{12}$ to 0″.01 with a maximum error of 0.″005 so that the last place can only be in error by 0″.06 on this account. This is not so with the higher differences, and it would require at least four decimals to be secure in the final first decimal. Godward avoids this difficulty in a most ingenious manner but exactly how he has done so is not explained—a simple but rather lengthy method, which was perhaps the one adopted, is by trial and error.

A numerical example will show the peculiarities of his method and its great ease in practical application.

From the Moon's place computed for noon and midnight we get

1861, April 25, Noon.	Dec.	− 20°	7′	20″.9
1/12	a_{-1}	−	11	5 .55
	b_{-1}	+	21	13 .2
	c_{-1}	+	2	27 .3
	d_{-1}	−		39 .2
Midn.	Dec.	− 21	59	14 .3

With the arguments b_{-1}, c_{-1}, and d_{-1}, we now enter Godward's tables

		1	2	3	4	5	6	7	8	9	10	11	12
1	Table I, b_{-1} gives	+ 57″.47	+ 8″.84	+ 0	+ 0	+ 1	− 1	+ 0	+ 0	+ 1	− 1	+ 0	+ 0
	Table II, c_{-1} gives	− 2 .03	+ 0 .09	+ 8	+ 8	+ 9	+ 9	+ 8	+ 9	+ 8	+ 8	+ 9	+ 8
	Table III, d_{-1} gives	− 0 .26	+ 0 .04	+ 0	+ 0	+ 1	+ 1	+ 0	+ 0	− 1	− 1	+ 0	+ 0
	Sum	− 55 .18	+ 8 .97	+ 8	+ 8	+11	+ 9	+ 8	+ 9	+ 8	+ 6	+ 9	+ 8

It will be remarked that $5''.46 = \frac{13}{288} b_{-1}$ and that

$$8''.84 = \frac{2}{13} \times 57''.47, \quad -2''.03 = \frac{n\,(n+1)\,(n-1)}{6} c_{-1}$$

when n is $\frac{1}{12}$ and so on for columns 1 and 2.

Then

$$F_{\frac{1}{12}} - F_0 = -11' \;\; 5''.55 + 55''.18 = -10' \;\; 10''.37$$

$$F_{\frac{2}{12}} - F_{\frac{1}{12}} = -10 \;\; 10 \;\; .37 + \;\; 8 \;\; .97 = -10 \;\; 1 \;\; .40$$

$$F_{\frac{3}{12}} - F_{\frac{2}{12}} = -10 \;\; 1 \;\; .40 + \;\; 8 \;\; .97 + 0''.08 = -9' \;\; 52''.35$$

and so on, or the calculation is as follows:

	−20°	7′	20″.9	
	−	10	10 .37	[+ 8″.97
	−20	17	31 .27	
	−	10	1 .40	[+ 8 .97 + 0 .08
	−20	27	32 .67	
	−	9	52 .35	[9 .05 + 0 .08
	−20	37	25 .02	
	−	9	43 .22	[9 .13 + 0 .11
	−20	47	8 .24	
	−	9	33 .98	[9 .24 + 0 .09
2	−20	56	42 .22	
	−	9	24 .65	[9 .33 + 0 .08
	−21	6	6 .87	
	−	9	15 .24	[9 .41 + 0 .09
	−21	15	22 .11	
	−	9	5 .74	[9 .50 + 0 .08
	−21	24	57 .85	
	−	8	56 .16	[9 .58 + 0 .06
	−21	33	24 .01	
	−	8	46 .52	[9 .64 + 0 .09
	−21	42	10 .53	
	−	8	36 .79	[9 .73 + 0 .08
	−21	50	47 .32	
	−	8	26 .98	
	−21	59	14 .30	agreeing with tabular place.

The figures have been arranged in (1) and (2) so as to make their derivation clear and a good deal of shortening occurs in practice, the schedule (1) not being used at all. Godward's quantities which follow 8.84 in schedule (1) would be uniformly = 0 if (again confining our argument to the 2d differences) 57″.47 and 8″.84 were *exactly* equal to $\frac{13}{288} b_{-1}$ and $\frac{2}{13} \times 57''.47$ respectively. The real values are 0″.0008 and 0″.0025 greater. Let us suppose that we had neglected these, *i. e.*, assume that as far as our 2d differences go Godward's quantities are *nil*, the calculation would stand as in the following column No. **1**. In column No. 2, the exact effect of Godward's quantities and the residual error are shown.

		Column No. 1.			Column No. 2.	
— 20	7	20.9	Error.	Error.		
—	10	10.37 — 0.0008	[+ 8.97	— 0.0017		
— 20	17	31.27 — 0.0008				
—	10	1.40 — 0.0025	[+ 9.05	— 0.0017		
— 20	27	32.67 — 0.0033				
—	9	52.35 — 0.0042	[+ 9.13	— 0.0017		
— 20	37	25.02 — 0.0075			Error.	Error.
—	9	43.22 — 0.0059	[+ 9.23	— 0.0017	43.22 — 0.0059 [+ 9.24	+ 0.0083
— 20	47	8.24 — 0.0134			8.24 — 0.0131	
—	9	33.99 — 0.0076	[+ 9.33	— 0.0017	33.98 + 0.0024 [+ 9.33	— 0.0017
— 20	56	42.23 — 0.0210			42.22 — 0.0110	
—	9	21.66 — 0.0093	[+ 9.41	— 0.0017	24.65 + 0.0007 [+ 9.41	— 0.0017
— 21	6	6.89 — 0.0303			6.87 — 0.0103	
—	9	15.25 — 0.0110	[+ 9.50	— 0.0017	15.24 — 0.0010 [+ 9.50	— 0.0017
— 21	15	22.14 — 0.0413			22.11 — 0.0113	
—	9	5.75 — 0.0127	[+ 9.57	— 0.0017	5.74 — 0.0027 [+ 9.58	+ 0.0083
— 21	24	27.89 — 0.0540			27.85 — 0.0140	
—	8	56.18 — 0.0144	[+ 9.64	— 0.0017	56.16 + 0.0056 [+ 9.64	— 0.0017
— 21	33	24.07 — 0.0684			24.01 — 0.0084	
—	8	46.54 — 0.0161	[+ 9.73	— 0.0017	46.52 + 0.0039 [+ 9.73	— 0.0017
— 21	42	10.16 — 0.0845			10.53 — 0.0045	
—	8	36.81 — 0.0178	[+ 9.81	— 0.0017	36.79 + 0.0022 [+ 9.81	— 0.0017
— 21	50	47.42 — 0.1023			47.32 — 0.0023	
—	8	27.00 — 0.0195			26.98 + 0.0005	
— 21	59	14.42 — 0.1218			14.30 — 0.0018	

The final results of columns Nos. 1 and 2 including the errors agree exactly, as they ought to do, but column No. 2 exhibits the effect of the temporary addition of 0″.01 twice to the difference of the second difference so that the final error is reduced to 0″.0018, whereas the error in column No. 1 is 0″.12.

The arrangement of the tables is so simple that an inexperienced computer can interpolate the Moon's place to twelfths, *i. e.* get out 13 positions in less than 10 minutes.

Cape of Good Hope, 24 May, 1901.

REPORT OF THE INTERNATIORAL ASTRONOMICAL CONFERENCE HELD AT THE PARIS OBSERVATORY IN JULY, 1900.*

M. M. LOEWY.

At the meeting of the International Permanent Committee held at Paris in 1896 regarding the photographic chart of the sky, it was decided by unanimous vote that another international astronomical conference should be held at the time of the World's Exposition. In conformity with this resolution and

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with the opinion expressed by the various members of the committee, the opening of the Congress took place on July nineteenth.

The meeting of 1900 derived particular importance from circumstances. The question was not only to decide the measures to be taken to assure the definite success of the monumental enterprise already in course of execution during some half-score years, but also to attack one of the greatest problems of astronomy, whose solution, sought for more than a century by different methods, seems ripe for serious progress.

This problem, having for its object the determination of the mean distance of the Sun from the Earth, expressed as a function of the diameter of the terrestrial globe, or, in astronomical language, the determination of the solar parallax, is the fundamental element which enters into all the evaluations of the distances between the stars.

This new research, of such high importance, is susceptible of accomplishment either by direct measurement or by photographic or by the two methods combined.

Thanks to the fortunate beginning of the conference at Paris, the harmony necessary for the execution of such is to-day assured. About fifty observatories of the principal civilized counties are already at work, conforming to the general plan proposed by the Congress. The astronomers have also given to the world the beautiful spectacle of a united fraternity which it would be difficult to surpass. In this, moreover, they remain faithful to a tradition inaugurated far in the past by their predecessors.

We recall, indeed, that toward the end of the last century the visit of Lalande to the most celebrated Observatory of Germany, at Gotha, was the occasion of a meeting of astronomers of different countries. They entered into an agreement for the systematic observation of several celestial phenomena. Among all intellectual workers, we venture to affirm that astronomers can claim the glory of having been the first to lead the nations to join hands over the frontiers, to distribute among themselves methodically the tasks which would be too extended for the length of one human life, or for the strength of one nation alone. It is the privilege of our science without doubt from the nature and the grandeur of the problems which it proposes, to persuade men to join in the pursuit of a common ideal, not only for the moment, through the impulse of enthusiasm, but for prolonged and deliberate working together in harmony.

CONSTRUCTION OF THE PHOTOGRAPHIC CHART OF THE SKY.

Since the first international meeting held at Paris in 1887 when, thanks to the initiative of Admiral Mouchez, the photographic exploration of the heavens was decided, each year has been marked by sensible progress and the realization of this gigantic piece of work, the success of which at the beginning seemed doubtful even to men of broad intelligence, has become to-day not only a fortunate certainty, but all astronomers are of the opinion that the value and utility of this enterprise surpass all the hopes of its promoters.

This great photographic work, in which eighteen observatories of both hemispheres are co-laborers has, as we know, a double aim.

1.—The formation of a general chart of the sky by the aid of photographs of long exposure; they have thus in view to obtain a representation of the actual state of the sky comprising all the stars down to the fourteenth magnitude. This inventory of the celestial sphere, which will require twenty-two thousand and fifty-four plates, will permit a more thorough examination of the general structure of the sidereal universe. It will furnish a valuable reference in regard to the apparition and disappearance of stars, their variability and their motion as a whole in certain regions of space.

2.—To make a series of plates of very short exposure based on the same number of negatives, containing the stellar images to the twelfth magnitude. This second photographic exploration of the sky is destined for the construction of a catalogue which will furnish accurate coördinates of two or three millions of stars. This work will serve as a basis for a very great number of researches of the highest precision. By means of these comparison stars it will be possible to determine the relative positions of all the other celestial bodies, especially comets and asteroids. We shall have, further, the possibility of determining with greater exactness and in a more complete manner the proper motions of the stars, and through this, to acquire a more positive knowledge of the motion of translation of the solar system.

We see, by this short exposure, what a wide field of investigation and discovery is offered to astronomers of to-day as well as to those of the future.

In any new research, whatever may be the theoretical value of the plan of execution established, *a priori*, the later realization

causes certain unforeseen difficulties to arise which must be remedied. We proceed inevitably through successive approximations to obtain the desired degree of perfection.

The various international congresses held at Paris from 1887 to 1900 have had just this for a task, to better adjust conditions of work and overcome the obstacles to the chart.

For the chart proper, that which results from the negatives of long exposure, many astronomers have thought that the method first specified did not present all the guarantees necessary against frequent mistakes to which we are exposed in interpreting the results obtained, and, for example, would not permit us always to recognize with certainty on a chart plate the true image of a faint star. This situation has delayed for many years the execution of the first work but the international conference of 1896 fortunately caused this uncertainty to disappear entirely in deciding that for the chart a series of plates should be made, each with three exposures. This solution, in effect, removes all doubt concerning the correspondence between the images and the stars photographed.

The French observatories have been the first to place in the hands of scientific men the chart plates executed on this plan. At the World's Exposition, in the section reserved by the Minister of Public Instruction, were three beautiful albums containing one hundred and seventy-seven of these charts. Each star is represented by three images forming a small triangle equilateral. It is thus impossible to confound a stellar image with spots resulting from impurities in the plate or from defects in the reproduction.

To give an idea of the wealth of these documents it will suffice to mention that on a great number of plates more than five thousand stars have been found.

In regard to the completion of the negatives for the photographic catalogue, considerable progress has been made, as has been shown by the information communicated at the last conference. By aid of the following table it will be seen that in many of the observatories the photographic work has been finished and in the others it is much advanced.

Observatories.	Zone in Declination.	Number of Photographs to be made.	Obtained.
	° °		
Greenwich	+ 90 to + 65	1149	1106
Rome	+ 64 to + 55	1040	476
Catania	+ 54 to + 47	1008	1008
Helsingfors	+ 46 to + 40	1008	1008
Potsdam	+ 39 to + 32	1232	1232

Observatories.	Zone in Declination.	Number of Photographs to be made.	Obtained.
Oxford	+ 31 to + 25	1180	736
Paris	+ 24 to + 18	1260	1260
Bordeaux	+ 17 to + 11	1260	402
Toulouse	+ 10 to + 5	1080	540
Algiers	+ 4 to — 2	1260	1260
San Fernando	— 3 to — 9	1260	1260
Tacubaya	— 10 to — 16	1260	746
Cape of Good Hope	— 41 to — 51	1512	1512
Sidney	— 52 to — 66	1400	1400
Melbourne	— 65 to — 90	1149	1149

We observe in this table the absence of three observatories upon which depended the completion of certain regions of the southern sky but which, for various reasons, have found themselves unable to fulfill their pledges. One of the principal objects of the conference of 1900 was particularly to examine measures for filling these vacancies. The efforts of the conference seem destined to achieve complete success.

For one, owing to the liberality and generosity of the government of the Argentine Republic a very valuable coöperation has even now been obtained, that of the national Observatory at Cordova, directed with so much renown by M. Thome; on another hand, the English astronomers have led us to hope for the concurrence of the Observatory of Perth (western Australia), already equipped with all necessary instruments and which, for a participation in our work, lacks only financial ability, a matter of relatively small importance. The conference of Paris has asked its president to make an appeal to the minister of the English colonies to render effective the willingness of M. Cooke, the eminent director of the Observatory of Perth. We have a hope, not without foundation, that this application will result in success. Finally, the initiative of a distinguished *savant* of Uruguay, M. Enrique Legrand, a very zealous partisan of the photographic chart enterprise, has decided the executive power of that country to present to their chamber of project for the creation at Montevideo of an Observatory especially devoted to the chart of the sky.

Many other measures were adopted by the international conference of 1900 to improve, under certain conditions, the material execution of the work undertaken. They touched upon questions too technical for their exposition to find a place in this report. We must confine ourselves to saying that the result will be that the different parts of the common undertaking will advance together and their character as a whole will be as harmonous and perfect as possible. The astronomers who are col-

laborating in this enterprise have a right to be proud of their task which they are accomplishing, the importance of which seems to grow from day to day and which promises results not yet apprehended.

To give but one example, recent researches now actually in progress prove that the chart properly so called, which will contain the images of almost thirty million stars, will render such service as we could hardly dare hope. Notwithstanding the blemishes always found in the paper of the charts, the intervention of the square *réseau*, which can be photographically transferred, renders us able to find the positions of this multitude of stars with a precision comparable to that given by meridian observations.

It would have been a rash project to attempt to reach such results by the process of direct observations. The united efforts of all the astronomers of the entire world during centuries would not suffice to carry to completion such an enterprise.

In casting a rapid glance over a past not yet distant, the mind finds itself impressed by the grandeur and fertility of the new methods as well as by the phenomenal progress in all the domains of science during the latter half of the century.

Determination of the Distance of the Sun from the Earth by the Aid of the Planet Eros.

To accomplish the task which it had imposed upon itself, the Congress of Paris had yet one more initiative to take to establish an understanding concerning the determination of the solar parallax which the recent discovery of the planet Eros will permit to decide with a precision hitherto unattainable. In effect, this asteroid arrives periodically, but at long intervals it comes within a very small distance of the Earth; in this case two observers, placed at the extremities of a diameter of the terrestrial globe, view the planet in very different directions the angle of which is susceptible of very exact measurement. This element, which in astronomical terms corresponds to what is called the parallax of the star, permits the direct calculation of the distance of Eros from the Earth. But when we know the distance between two planets, it becomes easy, by the aid of the laws of universal gravitation to deduce the mutual distances of all the the other stars of our solar system. We perceive then all the interest which attaches to this enterprise so fortunately begun. The astronomers hope thus to obtain not only a much more pre-

cise estimation of the distance of the Sun from the Earth but also that of the other bodies of our planetary world.

The strong organization of the observatories associated in view of the chart of the sky leads us to think that researches of that nature could be efficaciously undertaken by means of photograghic processes by several of these establishments whose situation would mark them for such a mission. The next apparition of Eros, during which this star will be easily observed, offers for this object a very favorable occasion.

But as these very subjects of study are susceptible of approach by other methods than the photographic, the Permanent Committee thought they should solicit, and have been happy to obtain, the concurrence of several eminent astronomers who are not co-operating in the chart of the sky. The conference, thus strengthened by numerous new able men, instructed by written or verbal communications, which it received in great number, did not hesitate to assume the task of elaborating a program for utilizing astronomical conditions which would not recur so favorably for nearly thirty years. We are happy to state that the program issued from these deliberations has everywhere met the warmest reception and has aroused a great scientific movement. At the moment this notice is written, this important research is in full course of execution. Each time that the state of the heavens permits, a hundred astronomers give themselves to the observation of the planet Eros during the whole night from the setting to the rising of the Sun. At this price only is it possible to satisfy in the most perfect manner the geometrical conditions of the problem. Each of them, in pursuing a work so trying, is sustained by the desire to contribute to scientific progress and is prepared to rejoice in the success of his fellow workers as in his own. These efforts, so noble and so disinterested, cannot fail to bear fruit.

We have a conviction that the international conference of 1900 held at the Observatory of Paris, will leave a lasting trace in the history of astronomy.

Appended is a list of the scientific men who took part in the conference:

PERSONNEL OF THE INTERNATIONAL CONFERENCE OF 1900.—MEMBERS OF THE BUREAU.

M. Loewy, President.
MM Bakhuyzen and Gill, Vice Presidents.
MM Dunér and Trépied, Secretaries.

MEMBERS OF THE COMMITTEES.

MM

Auguiano, A., Director of the Mexican Geodetic Commission at Tacubaya.
Baillaud, B., Director of the Observatory of Toulouse.
Bakhuyzen, H. G. von de Sande, Director of the Observatory of Leyden.
Christie, W. H. M., Director of the Observatory of Greenwich.
Dunér, N. C., Director of the Observatory of Upsala.
Gill, D., Director of the Observatory of the Cape of Good Hope.
Henry, Paul, Astronomer of the Observatory of Paris.
Henry, Prosper, Astronomer of the Observatory of Paris.
Loewy, M., Director of the Observatory of Paris.
Rayet, G., Director of the Observatory of Bordeaux.
Ricco, A., Director of the Observatory of Catania.
Tacchini, P.. Director of the Observatory of the College of Rome.
Thome, J. M., Director of the Observatory of Cordova.
Trépied, C., Director of the Observatory of Algiers.
Turner, H. H., Director of the Observatory of Oxford University.
Valle, F., Director of the National Observatory of Mexico at Tacubaya.
Viniegra, J., Director of the Observatory of San Fernando.
Weiss, E., Director of the Observatory of Vienna.

SCIENTIFIC MEN INVITED.

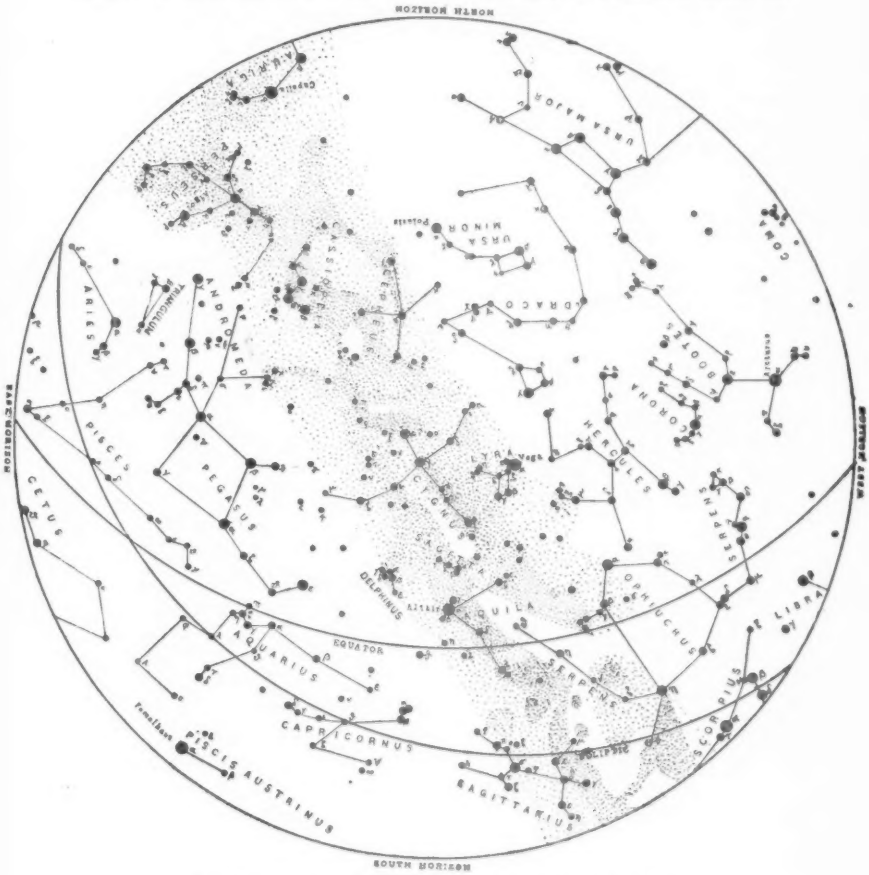
MM

André, G., Director of the Observatory of Lyons.
Bassot, General, Director of the Geographical Service of the Army, Paris.
Bigourdan, G., Astronomer at the Observatory of Paris.
Bonaparte, Prince Roland, of Paris.
Bouquet de la Grye, J. J. A., Member of the Academy of Sciences of Paris.
Callandreau, O., Member of the Institute, Astronomer of the Observatory of Paris.
Copeland, R., Director of the Observatory of Edinburgh,
Eginitis, D., Director of the National Observatory at Athens.
Elkin, W. L., Director of the Observatory of Yale University at New Haven.
Gaillot, A., Assistant Director of the Observatory of Paris.
Gautier, P., Constructor of Instruments of Precision, Paris.
Hagen, le R. P., Director of the Observatory of Georgetown College, Washington.
Hartwig, E., Director of the Observatory of Bamberg.
Laussedat, Colonel, Member of the Institute, Director of the Conservatory of Arts and Trades at Paris.
Legrand, E., Civil Engineer at Montevideo.
Leveau, G., Astronomer at the Observatory of Paris.
Lippmann, G., Member of the Academy of Sciences of Paris.
Lumière, Louis, Lyons.
Newall, H. F., Astronomer at the Observatory of Cambridge.
Perrotin, H., Director of the Observatory of Nice.
Poincaré, H., Member of the Academy of Sciences of Paris.
Rees, J. K., Director of the Observatory of Columbia University, New York.
Scheiner, J., Astronomer at the Observatory at Potsdam.
Stephan, E., Director of the Observatory of Marseilles.
Verschaffel le R. P., Director of the Observatory of Abbadia.
Wolf, G., Member of the Academy of Sciences, Honorary Astronomer of the Observatory of Paris.

PLANET NOTES FOR SEPTEMBER.

H. C. WILSON.

Mercury having been at superior conjunction Aug. 27, will be invisible to the naked eye until the last days of the month, when it may be possible to detect the



THE CONSTELLATIONS AT 9 P. M., SEPTEMBER 1, 1901.

planet low in the west soon after sunset.

Venus has been visible in the west after sunset during the past two months and is slowly coming into better position for observation. About eight-tenths of the lighted hemisphere is turned toward us but her distance is so great that her brilliancy is only a third of that when it is at its greatest. The new Moon and Venus will be in conjunction on the evening of Sept. 15.

Mars is still seen toward the south in the early evening. The planet has passed the star Spica and will during this month traverse the constellation Libra. The Moon and Mars will be in conjunction on the evening of Sept. 16. A correspondent asks what is the north polar star of Mars. We have not seen it stated anywhere, but a good many years ago Professor Oudemans, by means of Bessel's observations of the polar cap in 1830-37, found for the right ascension of the north pole of Mars 317° 34′ and for the declination + 50° 5′. This is about 8° northeast from the bright star α Cygni. The fourth magnitude stars π and ρ Cygni are within about 3° of the same point.

Jupiter and *Saturn* have been very conspicuous in the south during the summer months. During September they will still be in very good position for naked eye views in the early evening, but for telescopic observation their low altitude is very unsuitable. We have not been able at all to see the fine details of the surface marking of either planet this year. In the article in the early part of this number by Professor W. H. Pickering entitled "An Error in the American Ephemeris" there are some remarkable statements concerning the seeing in Jamaica which emphasize the necessity of the observer's being in suitable location in order to study the geography of the planets. Jupiter has completed his retrograde movement for the year and from now on will move eastward. Saturn will make the same turn on Sept 14. The Moon will pass Jupiter on the morning and Saturn on the evening of Sept. 21. Jupiter will be at quadrature, 90° east from the Sun, Sept. 27, at midnight.

Uranus in Scorpio will be at quadrature Sept. 5, and is at too low an altitude for satisfactory observation here.

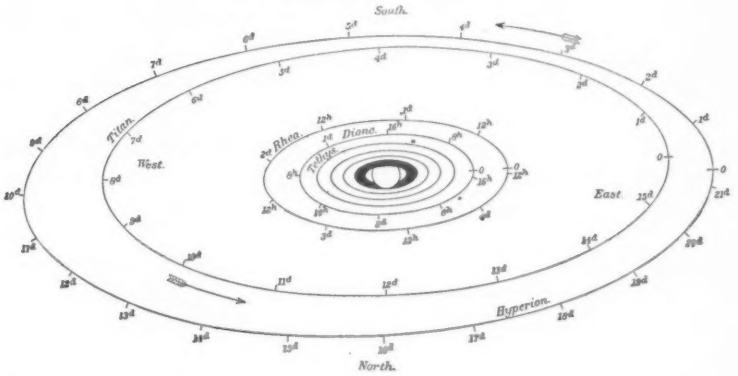
Neptune will be at quadrature, 90° west from the Sun, Sept. 25, and may be observed with a telescope in the morning. The position of the planet, Sept. 15, will be R. A. $6^h\ 6^m$ and Dec. + 22° 16′, less than 1° west from the star η Geminorum.

Phenomena of Jupiter's Satellites.

Central Standard Time.

	h	m					h	m			
Sept. 5	9	02	P. M.	I	Tr. In.	Sept 20	10	06	"	I	Oc. Dis.
	10	16	"	I	Sh. In.	21	7	18	"	I	Tr. In.
	11	20	"	I	Tr. Eg.		8	36	"	I	Sh. In.
6	6	20	"	I	Oc. Dis.		9	35	"	I	Tr. Eg.
	9	50	"	I	Ec. Re.		10	54	"	I	Sh. Eg.
7	7	03	"	I	Sh. Eg.	22	8	09	"	I	Ec. Re.
9	7	35	"	III	Ec. Dis.	23	10	16	"	III	Oc. Dis.
	10	40	"	III	Ec. Re.	27	7	59	"	II	Tr. In.
11	7	59	"	II	Oc. Dis.		8	38	"	III	Sh. Eg.
13	8	13	"	I	Oc. Dis.		10	40	"	II	Sh. In.
	8	20	"	II	Sh. Eg.		10	48	"	II	Tr. Eg.
14	6	41	"	I	Sh. In.	28	6	40	"	IV	Ec. Dis.
	7	41	"	I	Tr. Eg.		9	13	"	I	Tr. In.
	8	59	"	I	Sh. Eg.		9	47	"	IV	Ec. Re.
15	6	14	"	I	Ec. Re.		10	32	"	I	Sh. In.
16	6	19	"	III	Oc. Dis.	29	6	28	"	I	Oc. Dis.
	9	26	"	III	Oc. Re.		8	00	"	II	Ec. Re.
19	9	44	"	IV	Tr. In.		10	04	"	I	Ec. Re.
20	8	05	"	II	Sh. In.	30	6	00	"	I	Tr. Eg.
	8	14	"	II	Tr. Eg.		7	19	"	I	Sh. Eg.

The Satellites of Saturn.



APPARENT ORBITS OF THE SEVEN INNER SATELLITES OF SATURN, AT OPPOSITION IN 1901 AS SEEN IN AN INVERTING TELESCOPE.

I. MIMAS.

Period $0^d\ 22^h.6$

		h		
Sept.	4	6.4	P. M.	E
	5	5.0	"	E
	10	10.8	"	W
	11	9.4	"	W
	12	8.0	"	W
	13	6.6	"	W
	14	5.2	"	W
	18	11.1	"	E
	19	9.7	"	E
	20	8.3	"	E
	21	6.9	"	E
	22	5.5	"	E
	26	11.4	"	W
	27	10.0	"	W
	28	8.6	"	W
	29	7.2	"	W
	30	5.8	"	W

II. ENCELADUS.

Period $1^d\ 8^h.9$

		h		
Sept.	5	11.7	A. M.	E
	6	8.6	P. M.	E
	8	5.5	A. M.	E
	9	2.4	P. M.	E
	10	11.3	"	E
	12	8.2	A. M.	E
	13	5.1	P. M.	E
	15	1.9	A. M.	E
	16	10.8	"	E
	17	7.7	P. M.	E
	19	4.6	A. M.	E
	20	1.5	P. M.	E
	21	10.4	"	E
	23	7.3	A. M.	E
	24	4.2	P. M.	E

ENCELADUS.—Cont.

		h		
Sept.	26	1.1	A. M.	E
	27	10.0	"	E
	28	6.9	P. M.	E
	30	3.7	A. M.	E

III. TETHYS.

Period $1^d\ 21^h.3$

		h		
Sept.	5	9.4	P. M.	E
	7	6.7	"	E
	9	4.0	"	E
	11	1.3	"	E
	13	10.6	A. M.	E
	15	8.0	"	E
	17	5.3	"	E
	19	2.6	"	E
	20	11.9	P. M.	E
	21	9.2	"	E
	24	6.5	"	E
	26	3.9	"	E
	27	1.2	"	E
	30	10.5	A. M.	E

IV. DIONE.

Period $2^d\ 17^h.7$

		h		
Sept.	6	5.7	P. M.	E
	9	11.4	A. M.	E
	12	5.1	"	E
	14	10.8	P. M.	E
	17	4.5	"	E
	20	10.2	A. M.	E
	23	3.9	"	E
	25	9.6	P. M.	E
	28	3.3	"	E
Oct.	1	9.0	A. M.	E

V. RHEA.

Period $4^d\ 12^h.5$

		h		
Sept.	5	1.3	P. M.	E
	10	1.7	A. M.	E
	14	2.1	P. M.	E
	19	2.5	A. M.	E
	23	3.0	P. M.	E
	28	3.5	A. M.	E
Oct.	2	3.9	P. M.	E

VI. TITAN.

Period $15^d\ 23^h.3$

		h		
Sept.	6	4.3	P. M.	I
	10	5.2	"	W
	14	2.8	"	S
	18	1.2	"	E
	22	3.1	"	I
	26	4.2	"	W
	30	1.7	"	S

VII. HYPERION.

Period $21^d\ 7^h.6$

		h		
Sept.	4	7.0	P. M.	I
	9	5.0	"	W
	15	5.0	"	S
	20	10.0	A. M.	E
	25	1.0	"	I
	30	11.0	P. M.	W

VIII. IAPETUS.

Period $79^d\ 22^h.1$

		h		
Aug.	26	11.0	A. M.	E
Sept.	14	11.0	"	S
Oct.	3	6.0	P. M.	I

The Moon.

Phases.		Rises. (Central Standard Time at Northfield; Local Time 13m less.)	Sets.
		h m	h m
Sept. 5	Last Quarter	11 12 P. M.	2 37 A. M.
12	New Moon	5 37 A. M.	6 06 P. M.
20	First Quarter	1 18 P. M.	10 46 "
27	Full Moon	5 32 "	6 38 A. M.

There are no occultations of bright stars visible at Washington during the month after Sept. 5.

COMET AND ASTEROID NOTES.

Comet a 1901.—This comet like that of 1882 had so many independent discoverers that it will probably be known simply as the great comet of 1901. The first to see it appears to have been Viscara at Paysandu, Uruguay, who noticed it on the morning of April 12, 11 days before the other discoverers. The August number of "The Observatory" has as its frontispiece reproductions of a photograph of the comet taken at the Royal Observatory, Cape of Good Hope, May 4, and a drawing by Mr. Lunt, May 12. The photograph shows two bright, broad streams curving away from the nucleus. The exposure given was 15^m but it was in bright twilight so that the long faint tail could not be brought out. The drawing by Mr. Lunt shows a very bright tail extending along the north side of the Belt of Orion and a little more than double the length of that row of stars. A long faint tail diverges more than 30° from the bright one and extends three or four times as far. Between the two are two other narrow streams.

All accounts agree that to observers in the southern hemisphere the comet was a fine object in the western sky, in the early evening, during the first part of May. In the northern hemisphere it was seen only in bright twilight and very few observations were obtained. It is now probably beyond the reach of the telescopes.

Elements of Comet *a* 1901.—The following elements and ephemeris are by H. Thiele of Bamberg, and depend upon three normal places from the Cape and Cordoba observations. The normals are very closely represented.

ELEMENTS.

$T = 1901$, April 24.28845 Berlin M. T.
$\omega = 203°\ 02'\ 15''.1$
$\Omega = 109\ \ 38\ \ 53\ .1$ } 1901.0
$i = 131\ \ 04\ \ 49\ .3$
$\log q = 9.388827$

EPHEMERIS.

	R. A. h m s	Decl. ° ′ ″	log Δ.
Sept. 5	8 41 16.77	+ 10 56 04.5	0.53686
9	43 27.06	10 53 38.9	.53860
13	45 25.77	10 51 26.9	.53983
17	47 12.35	10 49 34.0	.54056
21	48 46.28	10 48 06.1	.54081
25	50 07.06	10 47 08.3	.54061
29	51 14.12	10 46 45.9	.53999
Oct. 3	52 06.91	10 47 04.2	.53896
7	52 44.72	10 48 08.7	.53755
11	8 53 06.73	+ 10 50 05.5	0.53580

Comet *b* 1901.—The following short sweeping ephemeris of Encke's periodic comet, computed by Thonberg, was cabled from Kiel Aug. 4. A copy of the cablegram was received at Goodsell Observatory, through the courtesy of Harvard College Observatory, on Aug. 5. On the next morning the comet was found by the writer, with the 16-inch telescope, close to the place extrapolated from the ephemeris. The comet was then exceedingly faint in the moonlight and presented the appearance of a small nebula with no nucleus and only as light central condensation. On Aug. 16 in the absence of moonlight the comet was much brighter and more extended, with a 12 or 13 magnitude nucleus near the sunward edge of the strongest condensation of the coma. It was quite conspicuous in the 16-inch telescope and easily seen in the 5-inch finder.

SWEEPING EPHEMERIS FOR ENCKE'S COMET.

Greenwich Midn.	R. A.	Decl.	Brightness.
	h m s	° ′	
Aug. 9	6 27 24	+31 26	1.00
13	6 56 04	30 44	
17	7 26 12	29 34	
21	7 56 36	+27 49	2.00

OBSERVED POSITION OF THE COMET.

Greenwich M. T.	R. A. App.	Decl. App.	Observer.
h m s	h m s	° ′ ″	
Aug. 5 21 25 0	6 02 02.79	+31 42 30.5	Wilson
16 21 39 42	7 20 24.62	+29 50 41.6	Wilson

We had expected before going to press to insert the portion of Thonberg's ephemeris for September, but Nos. 3732 and 3733 of the *Astronomische Nachrichten*, the latter of which contains the ephemeris, appears to have miscarried in the mails, while the later number 3734 is at hand.

Encke's Periodic Comet was well seen at $3^h\ 45^m$ A. M. this day Aug. 14, 1901. It was then in α, $6^h\ 58^m$ and in $+\ \delta\ 30°\ 34'$, motion rapid. Large, faint diffuse with only slight indication of nucleus. Sky clear, air steady and observation satisfactory. EDGAR L. LARKIN, Director.

MOUNT LOWE OBSERVATORY, Cal., Aug. 14, 1901.

Asteroids Named.—The following minor planets have recently received names:

No.	Preliminary Designation.	Name.	No.	Preliminary Designation.	Name.
(393)	1894 BG	Lampetia	(418)	1896 CV	Alemannia
(399)	1895 BP	Persephone	(419)	1896 CW	Aurelia
(407)	1895 CC	Arachne	(450)	1899 EV	Brigitta
(408)	1895 CD	Fama	(455)	1900 FG	Bruchsalia
(415)	1896 CO	Palatia		1901 GJ	Kilia
(417)	1896 CT	Suevia			

Asteroid (456) 1900 FH.—In *A. N.* 3734 Dr. A. Berberich gives the following elements of this planet, derived from 36 observations in June and July 1900.

Epoch June 4.5, 1900 Berlin M. T.

$$
\begin{aligned}
M &= 16°\ 24'\ 45''.8 \\
\omega &= 2\ 20\ 53\ .4 \\
\Omega &= 229\ 39\ 57\ .0 \\
i &= 14\ 28\ 05\ .8 \\
\phi &= 10\ 35\ 25\ .3 \\
\mu &= 762''.716 \\
\log a &= 0.445096
\end{aligned}
\Bigg\} 1900.0
$$

ELEMENTS.

1901	R. A.	Decl.	log *r.*	log Δ
	h m s	° ′		
Sept. 20	0 16 03	+17 45.5	0.4888	0.3262
22	14 30	17 31.8		
24	12 57	17 17.4	0.4896	0.3253
26	11 23	17 02.4		
28	9 50	16 46.9	0.4904	0.3253
30	8 18	16 30.9		
Oct. 2	6 46	16 14.3	0.4911	0.3362
4	5 16	15 57.4		
6	3 48	15 40.2	0.4919	0.3280
8	2 22	15 22.7		
10	0 00 58	15 05.0	0.4926	0.3308
12	23 59 37	14 47.1		
14	58 20	14 29.2	0.4934	0.3346
16	57 06	14 11.2		
18	55 56	13 53.2	0.4942	0.3392
20	54 50	13 35.4		
22	53 50	13 17.7	0.4949	0.3445
24	52 54	13 00.2		
26	52 02	12 43.0	0.4956	0.3506
28	51 14	12 26.1		
30	23 50 28	+12 09.5	0.4963	0.3574

Magnitude 13.0

Asteroid (391) Ingeborg.—This planet was rediscovered at Heidelberg Aug. 8, and an approximately corrected ephemeris is given in *A. N.* 3734 by Dr. A. Berberich. The portion for September is here given:

EPHEMERIS.

1901.	R. A.	Decl.	log *r.*	log Δ.
	h m s.	° ′		
Sept. 4	0 39 09	+36 28.9	0.2049	9.8803
6	39 54	36 08.8		
8	40 33	35 45.5	0.2049	9.8670
10	41 04	35 18.9		
12	41 28	34 49.0	0.2050	9.8544
14	41 45	34 15.6		
16	41 55	33 38.8	0.2053	9.8426
18	42 00	32 58.5		
20	42 00	32 14.8	0.2057	9.8320
22	41 55	31 27.6		
24	41 45	30 37.0	0.2063	9.8228
26	41 32	29 43.1		
28	41 18	28 46.1	0.2070	9.8154
30	41 01	27 46.0		
Oct. 2	0 40 42	+26 43.2	0.2079	9.8100

Photographic Search for Periodic Comets.—A large number of photographs were taken by Dr. Delisle Stewart, with the 24-inch Bruce telescope at Arequipa, Peru, during last October, November and December, in search for the periodic comets of Brorsen, Swift and Barnard (1884 II), with a negative result in each case. The exposures averaged about one hour and in many cases a guiding apparatus was used which took account of the computed movement of the comet, but in no case was any trace of a comet found.

VARIABLE STARS.

New Variable Stars.—In A. N. 3718, Prof. W. Ceraski announces two new variable stars. The first was found in December, 1900, by Mme. L. Ceraski in studying the photographs taken by M. S. Blajko, assistant at the Observatory of Moscow, but the announcement was deferred for verification. The position of the star from the measures of two plates is

72.1901 Lyræ.

1855.0 R. A. 19^h 07^m $37^s.01$; Decl. $+33°$ $10'$ $12''.6$
1900.0 19 09 17 .62; $+33$ 14 38 .1.

the star at maximum is of the 10th magnitude or brighter while at minimum it is below the 12th magnitude. Its period appears to be either 0.81 or 0.27 years.

The other variable is

BD $-12°.5202$ = 73.1901 Scuti
1855.0 R. A. 18^h 46^m $19^s.7$; Decl. $-12°$ $46'.9$ 9.3 mag.

From his observations between April 26 and May 11, 1901, M. S. Blajko concludes that this star is of the Algol type. Its period is about $22^h.9$ and its brightness varies in five hours from 9.1 to 9.6 mag.

New Variable κ (74.1901) Persei.—From observations extending from March 21 to May 24 (A. N. 3720), Mr. Paul Guthnick concludes that this star is variable, the range during that period of time being from 3.6^m to 4.25^m and back. As this star was frequently used as a comparison star for Nova Persei, it is important that its law of variation be determined. The color of κ Persei is deep orange.

New Variable 75.1901 (36 Fl.) Persei.—Mr. Fr. Deichmuller in A. N. 3720, announces that the star 36 Persei is variable, it having increased from 5.6^m on Mar. 28 to 5.1^m on May 22. He is supported in this claim by Mr. Paul Guthnick who gives a similar series of observations of the star. This star was also used frequently as a comparison star for Nova Persei.

New Variable Star 76.1901 Ophiuchi.—This star was discovered by Rev. Thomas D. Anderson of Edinburgh. It is not found in Argelander's *Durchmusterung*, its approximate position being

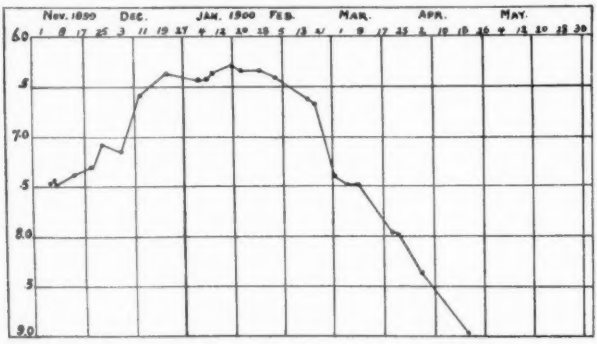
1855.0 R. A. 17^h 49^m 39^s; Decl. $+11°$ $11'$.

On Oct. 29, 1900 it was $0^m.1$ brighter than BD $+11°.3296$ and on Nov. 9 was equal to BD $+11°.3293$, while on July 15, 1901 it was invisible in a 3-inch refractor, although a $10.^m1$ star near its place could be seen without difficulty.

Nova Persei, No. 2.—An examination of the Draper photographs of the spectra of Nova Persei, No. 2, by Mrs. Fleming, shows that like other novæ, it has been gradually changing into a gaseous nebula. The resemblance to the nebula N. G. C. 3918 is now so close that in a photograph taken on June 19, 1901, no marked difference was noted, except that the nebular line, 5007, is about eight times as bright as Hβ in the nebula, and only equal to it in the Nova. The lines 3869, 3970, (Hε), 4102, (Hδ), 4341, (Hγ), 4688, 4862, (Hβ), 4959, and 5007, are common to both and, except the last, have nearly the same relative intensities. Four bright lines between Hγ and Hβ appear faintly in the Nova and are not present in the nebula, while one, 4364, is seen in the nebula but not in the Nova, perhaps owing to the proximity of Hγ. EDWARD C. PICKERING.

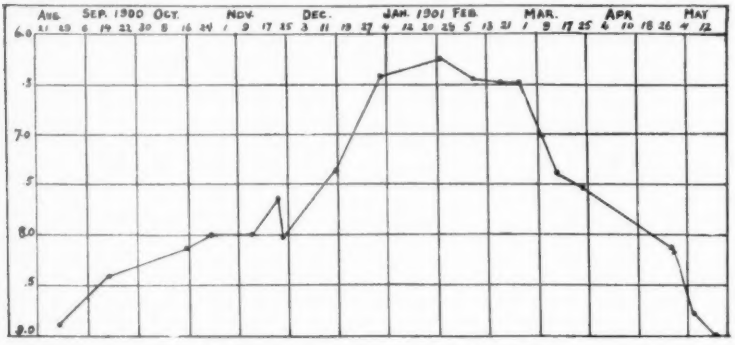
June 25, 1901.

Observations of the Variable Star 7609 τ Cephei, made with a Lemaire field-glass magnifying about 4½ times, with curves showing maxima about 1900, Jan. 14 and 1901, Jan. 29. Probably below $8^m.0$ the observations would be doubtful, owing to faintness, though I can "glimpse" $9^m.0$ on a good



Maximum of τ Cephei in 1899-1900.

night. I am afraid I am a little off in Nov. 1900, though there seems to be a similar variation on a smaller scale in November 1899, the 25th.



Maximum of τ Cephei in 1900-1901.

As magnitudes of comparison stars I have used those obtained at Harvard viz:

$c = 6.04$	$f = 7.69$
$d = 6.68$	$g = 8.18$
$e = 7.12$	$k = 8.78$

My observations are as follows:

1899, Nov.	4	7.48	1899, Dec.	9	6.59
	5	7.41		20	6.36
	6	7.48	1900, Jan.	2	6.44
	13	7.38		6	6.43
	20	7.30		8	6.36
	21	7.30		16	6.29
	24	7.07		19	6.33
Dec.	2	7.13		27	6.33

1900, Feb.	2	6.40	1900, Nov.	21	7.62
	15	6.61		23	8.31
	18	6.68	Dec.	14	7.35
	26	7.40	1901, Jan.	1	6.40
Mar.	3	7.48		25	6.23
	7	7.48	Feb.	7	6.42
	20	7.94		18	6.46
1900, March	23	7.97		26	6.46
April	1	8.34	March	7	7.00 ±
	19	8.96		12	7.38
August	25	8.89		23	7.52
Sept.	14	8.40	April	27	8.10 ±
Oct.	15	8.12		28	8.18 ±
	25	8.00	May	6	8.78
Nov.	10	8.00		15	9.00 ±

GEORGE L. JONES.

MEDFORD, Mass., May 17, 1901.

Brightness of Nova Persei.—The following table gives the estimates of brightness of the new star by the writer at Northfield. The estimates were made with the naked eye up to April 8, except on April 3, when a 1 inch sextant telescope was used. After April 8 the estimates were made with the aid of a pair of field glasses of 1½ aperture. From March 9 on the comparison stars were all taken in the constellation Perseus and the greek letters therefore represent the stars of that constellation. The numerals between the greek letters indicate the number of steps of estimated difference in brightness between the stars. The letter *N* represents the new star and the numbers in parenthesis (25), (37), (38) are the numbers of stars in Professor Hagen's list of comparison stars given in the April number of Popular Astronomy.

The estimates after March 11 have been reduced by the method of least squares, an equation being formed for each star of the form

$$a + b\,s = m,$$

in which s is the number of steps from an assumed zero star, m is the mean of the two magnitudes given for each star in Prof. Hagen's list, a and b are undetermined constants. As soon as a and b have been determined from all of the comparison stars, an equation of the same form gives m for the Nova. The resulting values are given in the last column.

The fluctuations in the light of the star have been very marked, amounting to a half magnitude above and below the mean curve of the waning light. These fluctuations show a tendency to be periodic, but the actual period and whether it is regular or variable is uncertain.

ESTIMATES OF THE BRIGHTNESS OF NOVA PERSEI.

Central Standard Time.		Estimates.	Reduced Mag.
Feb. 26	8:00	N = α Tauri.	1.0
27	8:00	N = α Persei.	1.9
Mar. 2	8:00	α Persei 2 N 1 β Persei.	2.3
4	8:00	α Persei 4 N = δ Cassiop. 1 β Persei	2.7
5	8:00	α Persei, γ Cassiop., α Cassiop., β Cassiop., β Persei, N, δ Cassiop., γ Persei, ε Persei.	2.6
6	8:00	γ Persei = ε Persei, N, δ Persei.	3.0
9	8:00	ε, N, ν.	3.5
11	8:00	α 5 β 10 ε 2 γ 1 δ 5 η = N 1 κ 1 ν 1 ι 1 θ 1 σ 1 ψ 3 *l.*	3.90
15	8:00	α 10 β 10 γ 2 ε 2 δ 3 η = N 1 κ 1 ν 1 τ 1 ι 1 θ 1 σ 1 ψ	3.83

ESTIMATES OF THE BRIGHTNESS OF NOVA PERSEI.—Continued.

Central Standard Time.		Estimates.	Reduced Mag.
16	8:00	κ ½ N ½ ν.	3.98
20	8:00	γ 2 ϵ 2 δ 1 N 2 κ 1 ν 1 θ 1 σ 1 ψ.	3.63
21	8:00	α 7 β 7 γ 1 ϵ 2 δ 3 ρ 2 η 1 $\kappa = \nu$ 1 $\theta = \iota$ 1 τ 1 σ 1 ω 1 N 1 ψ 5 *l*	4:38
	9:10	α 7 β 7 γ 1 ϵ 2 δ 2 ρ 2 η 1 ν 1 κ 2 θ 1 ι 1 τ 1 σ 2 ω 1 N 1 ψ 3 *l*	4.55
22	7:30	$\kappa = \nu$ 2 N = ι through space between clouds.	4.17
27	8:45	α 15 ϵ 1 γ 2 δ 1 β 3 ρ 5 κ 1 ν 1 N 1 θ 1 ι 1 δ	4.15
28	8:20	α 5 β 7 γ 2 ϵ 1 $\delta = \rho$ 2 η 5 $\tau = \kappa = \nu$ 1 ι 1 θ 1 σ 3 ψ = N = ω 3 *l*.	4.68
30	9:00	κ 1 ν 1 N 1 ι 1 θ 1 σ 3 $\psi = \omega$.	4.10
31	8:30	$\kappa = \nu$ 2 N = $\iota = \theta$ 1 σ 3 ψ.	4.19
April 1	7:30	$\kappa = \nu$ = N? slightly hazy.	3.98
2	9:00	N invisible to naked eye in moonlight; ω and ψ visible; *l* invisible	<4.47
3	9:00	*l* 5 (25) = N 1 (37); with 1 inch telescope.	5.29
8	9:00	κ 1 ν 2 N 2 σ 3 ψ; slightly hazy.	4.17
10	10:15	κ 5 *l* 5 (25) 2 N 2 (37) 5 (38); with field glasses.	5.49
13	9:00	ν 2 $\kappa = \theta = \iota$ 1 σ 2 ψ 1 N 1 *l* 3 (25) 2 (37) 5 (38)	4.76
18	9:00	ν 1 κ 1 $\theta = \iota$ 2 σ 2 ψ = N 2 *l* 3 (25) = (37) 7 (38).	4.68
19	8:45	$\nu = \kappa = \theta$ 1 ι 2 σ 1 ψ 3 *l* 5 (25) = (37) = N 10 (38)	5.33
20	9:00	$\nu = \kappa = \iota$ 1 σ 2 ψ 3 *l* 5 (25) = (37) 1 N 9 (38).	5.49
22	9:15	ν 1 $\kappa = \iota$ 1 σ 2 ψ 5 N 1 *l* 5 (25) = (37) 10 (38).	4.88
23	9:15	$\nu = \kappa$ 1 $\theta = \iota$ 2 σ 2 ψ = N 5 *l* 3 (25) = (37) 10 (38).	4.53
26	8:45	ν 2 κ 2 $\iota = \sigma$ 2 ψ 5 *l* 5 (25) = N = (37) 10 (38).	5.41

From the same estimates I find the magnitudes of the comparison stars in Perseus to be as follows:

Star.	Estimated Mag.	Mag. in Hagen's List.	Difference.	Star.	Estimated Mag.	Mag. in Hagen's List.	Difference.
α	1.9	2.0	−0.1	ι	4.2	4.2	0.0
β	2.5	2.4	+0.1	θ	4 2	4.3	−0.1
γ	3.2	3.1	+0.1	σ	4.3	4.5	−0.2
δ	3.5	3.2	+0.3	τ	4.1	4.2	−0.1
ϵ	3.3	3.0	+0.3	ψ	4.5	4.2	+0.3
ρ	3.6	3.8	−0.2	ω	4.5	4.8	−0.3
η	3.8	3.9	−0.1	*l*	4.9	5.1	−0.2
κ	4.0	4.0	0.0	(25)	5.4	5.4	0.0
ν	4.0	4.0	0.0	(37)	5.4	5.3	+0.1
				(38)	6.4	6.5	−0.1

The above note was written for the June and July number of POPULAR ASTRONOMY but for lack of space was not inserted. I did not observe the star during May, June and July, but on Aug. 5 found it to be of the 5.5 magnitude. Observations since that time indicate an average magnitude 6.0 with only slight variations.

H. C. WILSON.

Nova Persei. Mira.

June 3, 3:45 A. M.—The Nova is not visible in an opera glass though 36, 32, and 30 (Fl. cat.) were seen.

" 10, 3:15 A. M.—It is of 6.5 mag.

" 11, 3:10 A. M.—It is brighter than 6th mag. but not as bright as 30.

" 15, 3:00 A. M.—Equal to 36 of 5.3 mag.

" 23, 3:00 A. M.—Not as bright as 30 but brighter than 6.5. Probably of 6th magnitude.

" 27, 2:10 A. M.—It is of 6th magnitude.

Mira whose maximum was predicted in the "Observatory" for June 28th, was observed on the 27th 3:00 A. M. and seemed equal to Gamma Ceti, both stars having the same altitude. ROSE O'HALLORAN.

SAN FRANCISCO, July 1st, 1901.

Variable η Argus.—A telegram from Cape Town, May 6, states: "The spectrum contains bright lines or bands, is the same as that of Nova Aurigæ. *Gill*" (A. N., No. 3711.)

GENERAL NOTES.

Our readers have waited a few days longer than usual for the appearance of our publication this time, for reasons partly beyond our control. Its contents, however, are so excellent and so generally useful that we hope its late appearance will be forgotten in its perusal.

Dark Transit of Jupiter's Third Satellite.—August 22, $6^h\ 30^m$; 90th meridian M. T. On turning my 5-inch telescope on Jupiter for the purpose of observing the shadow of No. 1, I found projected upon the disk about half way between the equatorial belts and the north pole of the plant the dark image of satellite No. 3. The color was not jet black, as that of the shadow of No. 1, but was dark chocolate, quite distinct and well defined. No change in appearance was detected during the 30 minutes of close observation when intervening clouds prevented my witnessing the egress. I have witnessed similar phenomena on three previous occasions, viz.: on Sept. 2d, 1890, Nov. 6th, 1891, and Dec. 19th, 1891, all of which were recorded in the issues of this Journal next following the events. Lat., 38° 27′ N.; Long., 85° 40′ W.; Power, 180.

Is there record of any other person having witnessed four dark transits of Jupiter's third satellite? WILLIS L. BARNES.

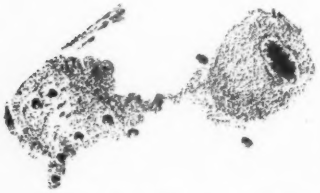
CHARLESTOWN, Ind., Aug. 22, 1901.

The Cape of Good Hope Observatory.—We are favored by David Gill, Director of the Cape of Good Hope Observatory with copies of the Cape Catalogue of 1905 stars, for the equinox of 1865.0, from observations made at the Royal Observatory of the Cape of Good Hope during the years 1861 to 1870 under the direction of Sir Thomas Maclear, reduced and published by David Gill, now Royal Astronomer at the Cape. Also, the results of meridian observations made at the same Observatory by the same person during the years 1866 to 1870, and reduced and printed by the present director of the Observatory. The two volumes are neatly and substantially bound, and are valued as additional catalogues for needed and useful star references.

In the same package, came other noble volumes. Annals of the Cape Observatory Vol. V. The Cape Photographic Durchmusterung for the equinox of 1875 by David Gill and J. C. Kapteyn, Professor of Astronomy at Groningen. This fine quarto volume contains 671 pages, 88 of which are devoted to decriptive matter mainly. The balance presents the photographic zone work, from $-53°$ to $-89°$.

In the report of the Paris conference for 1900, elsewhere printed, it will be noticed that the Cape Observatory is one of those coöperating in that large and important piece of photographic work. The zone allotted to that Observatory

was — 41° to — 51°. The work of taking the negatives for this zone is already completed, consisting of 1512 plates. Also, Researches on Stellar Parallax with the Cape Heliometer, has a large number of good things in it that we hope to specify at another time. It forms Part II, of Vol. VIII of the Annals of the Observatory.



SUNSPOT, MAY 22, 10 A. M. 1901.

Sunspot Observations.—After several months of solar inactivity, a spot in two sections was seen a few degrees inside the east limb on the 19th of May last. It was in N. lat. 8 degrees, and measured fully 72,000 miles in length, the elongation being nearly in an east and west direction. The changes in umbræ and penumbræ were considerable from day to day, the accompanying drawings showing remarkable developments when it had attained its greatest size. The penumbræ were rather faint and had several well defined clear spaces within them. The two sections were visible until the 30th when near the west limb. On June the 15th solar rotation again brought it into view, but the foremost, which was much larger than the section following, was barely of average size. The umbra was oval and bridged. On the 17th, the smaller spot was no longer identifiable among the few very minute markings that were adjacent.

Another pair of spots, one following the other, and of scarcely average size, appeared in the S. W. quadrant in S. lat. 20 degrees on the 23rd of June. Both groups, which were in about the same longitude, were very close to the west limb on the 25th of the month and could not be discerned in a four-inch telescope after that date. At the present stage of minimum a revival of activity is of especial interest, as it may herald a returning maximum.

SAN FRANCISCO, July 1st, 1901.

SUNSPOT, MAY 23, 9 A. M., 1901.

ROSE O'HALLORAN.

Lick Observatory Bulletin No. 2 is just received accompanied by a note by Professor Campbell explaining the delay in mailing. This Bulletin gives the meridian circle observations of 352 reference stars, for the planet Eros at opposition, 1900. Each star has two determinations of position, except one variable star in right ascension $4^h\ 46^m\ 15^s$, which was too faint to observe, on two occasions when looked for, being below the 10th magnitude. In Chandler's list it is V Tauri, and declines to 13.5 magnitude at minimum. This list is designated the second. The first list of reference stars was finished Dec. 7, 1900, and the first half of 2^h in right ascension of this list was completed at that time Bad observing weather followed, but the work was completed Jan. 29, 1901. In all, some more than 900 observations were made on this including those of fundamental circumpolars and nadirs. Mr. Crawford assisted in reading the

microscopes for 400 observations, but Mr. R. H. Tucker did all the remaining work including the reductions without assistance.

The two lists of Eros stars have required, in all, some more than 2000 observations including circumpolars and nadirs.

The maximum number of observations, for a night, was 90; the average was 40, for unbroken nights.

The August Meteors of 1901.—In *Nature* of Aug. 22, W. F. Denning has an important, condensed report of the August meteors of 1901. He states that a considerable number of meteors were observed, in various places, Aug. 10, 11, 12. The maximum appears to have occurred on the 13th, a little later than usual, which was on Tuesday morning. The state of the sky did not allow the "progress of the display to be fully observed during its rise culmination and fall.

"The first marked indication of the Perseids, as a definite shower became apparent on July 21, when the writer, (Mr. Denning) recorded five swift streak-leaving meteors from a radiant at 23° + 52°, but two of them were imperfectly seen, and their directions could be only roughly noted, so that the resulting radiant was not very satisfactory, though there could be no doubt of its actual existence, either at, or very near, the position assigned."

Moonlight and clouds prevented tracing the showers between July 21 and Aug. 10. On the latter day the display was moderately rich. Between $9^h\ 30^m$ and 15^h the total number of meteors seen were 102, although nearly half of this time was used in registering their paths. Of this 102, 55 were Perseids.

On Aug. 11, from $9^h\ 30^m$ to $12^h\ 30^m$, 72 meteors were noticed and 49 were Perseids.

Between July 21 and August 18, the right ascension of the radiant differed to 32°, as shown in the following table:

July 21	23° + 52°	5 meteors
Aug. 10	44 + 58	55 "
11	45 + 58	49 "
15	51 + 58	6 "
16	53 + 58	5 "
18	55 + 59	8 "

"Four meteors seen Aug. 10 were also recorded by Professor A. S. Herschel at Slough, and their real paths have been determined. Their heights, etc., are included in the following table, in which are also given the result for the fire-ball of Ang. 11, which left a streak for about a minute amongst the stars of Aquarius. It must have been a magnificent object from the English Channel.

			Mag.	Height at first miles.	Height at end miles.	Path miles.	Velocity per sec. miles.	Radiant.
	h	m						° °
Aug. 10	10	41	3 — 2	91	72	20	24	278 + 67
	12	00	1	76	51	36	50	44 + 58½
	12	16	2 — 1	69	50	27	39	42 + 57
	12	19	3 — 2	72	60	33	25	149 + 60
Aug. 11	11	2	2 × ♀	95	56	64	——	45 + 58

Long Exposure Photographs.—Mr. W. Stratonoff in *Astronomische Nachrichten*, No. 3710 gives the results of counting the numbers of stars to be found upon photographic plates with very long exposure. He used a refractor of 33 cm. aperture and has made some exposures of 20, 25 and 30 hours duration. The longest was upon the double cluster in Perseus, and was the work of 10 nights, from the 5th to the 17th of August 1899. The number of stars upon

four square degrees of this plate was 45,000, but this is less than was to be expected from the position of the cluster in the middle of the Milky Way. The following tables gives the results of the counts upon several photographs of different duration, those of the region about η Argus having been taken at the Cape of Good Hope:

Exposure.	No. of Stars per Square Degree.	Exposure.	No. of Stars per Square Degree.
Pleiades.		*h* and χ Persei.	
h		h	
0.1	100	0.1	250
0.3	160	0.4	600
3.0	600	2.0	2000
10.0	1300	5.0	4500
25.0	1700	30.0	11000
Ring Nebula in Lyra.		η Argus.	
h		h	
0.5	600	3¼	10000
1.0	1900	12	50000
10.0	6000	24	100000
20.0	10000		

Visibility of the Satellites of Jupiter.—The following very interesting discussion ensued upon the reading of a paper entitled "The Limits of Vision" by Mr. Edwin Holmes, before the meeting of the British Astronomical Association, June 26, 1901, as reported in "The Observatory" for August. The slightest telescopic aid always renders the four satellites of Jupiter very conspicuous and there is no doubt but that were it not for the glare from the planet they would ordinarily be visible to the naked eye.

"Mr. W. T. Lynn agreed with Mr. Holmes in thinking that no one ever saw the satellites of Jupiter before the telescope was invented. It seemed to be quite out of the question. The Chinese and Japanese had been said to have seen them long before; but if anyone saw a star near Jupiter with the naked eye, it did not follow that it was one of the planet's satellites.

"Mr. A. Kennedy said he recollected an old lady, who had wonderful sight, plotting down the satellites of Jupiter on paper from the heavens, and when the planet was looked at through a glass it was found her positions were quite right.

"Mr. T. Clapton said he remembered a young lady, who had very keen sight, remarking when he pointed Jupiter out to her, "what are those little stars very close?" At his request she plotted them on paper, and they were quite right regarding position. He also remembered seeing the satellites of Jupiter when about 14 years of age, and some seven years ago his son and himself believed they saw a satellite of Jupiter, at any rate their observations were in perfect agreement.

"Mr. G. J. Newbegin said he knew two instances of the satellites of Jupiter having been seen with the naked eye. One instance was that of a gentleman, who, upon looking at Jupiter with the naked eye, asked what the small stars on one side were, and then upon looking through the telescope said "They are on the other side now."

"Mr. Crommelin said the Rev. T. W. Webb, in his book on 'Celestial Objects for Common Telescopes,' laid claim to having seen Jupiter's two outer satellites merely with an ordinary concave eyeglass, which corrected his near sight.

"Mr. S. A. Saunder said he could not help thinking that in view of the amount of short sight, long sight, and astigmatism that existed there must be a large number of eyes having these defects in smaller and varying degrees which passed as normal.

"Mr. J. M. Offord remarked that Mr. Holmes had said that there was no evidence of the ancients having seen Saturn's rings; but the Chaldæans represented Saturn as a figure surrounded by a ring. This might have been pure chance, still it was a curious fact."

The Apex of the Sun's Way.—In A. N. 3721-22 Prof. J. C. Kapteyn gives the results of a new investigation of the solar motion. He finds for the apex of the Sun's way, or the point toward which it is moving,

R. A. (1875) $273^{\circ}.6 \pm 1^{\circ}.3$; Decl. (1875) $+ 29^{\circ}.5 \pm 1^{\circ}.1$.